The Association
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# Freehand Drawing and Pictorial Illustration For Draughtsmen.

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By W. H. KERRY.

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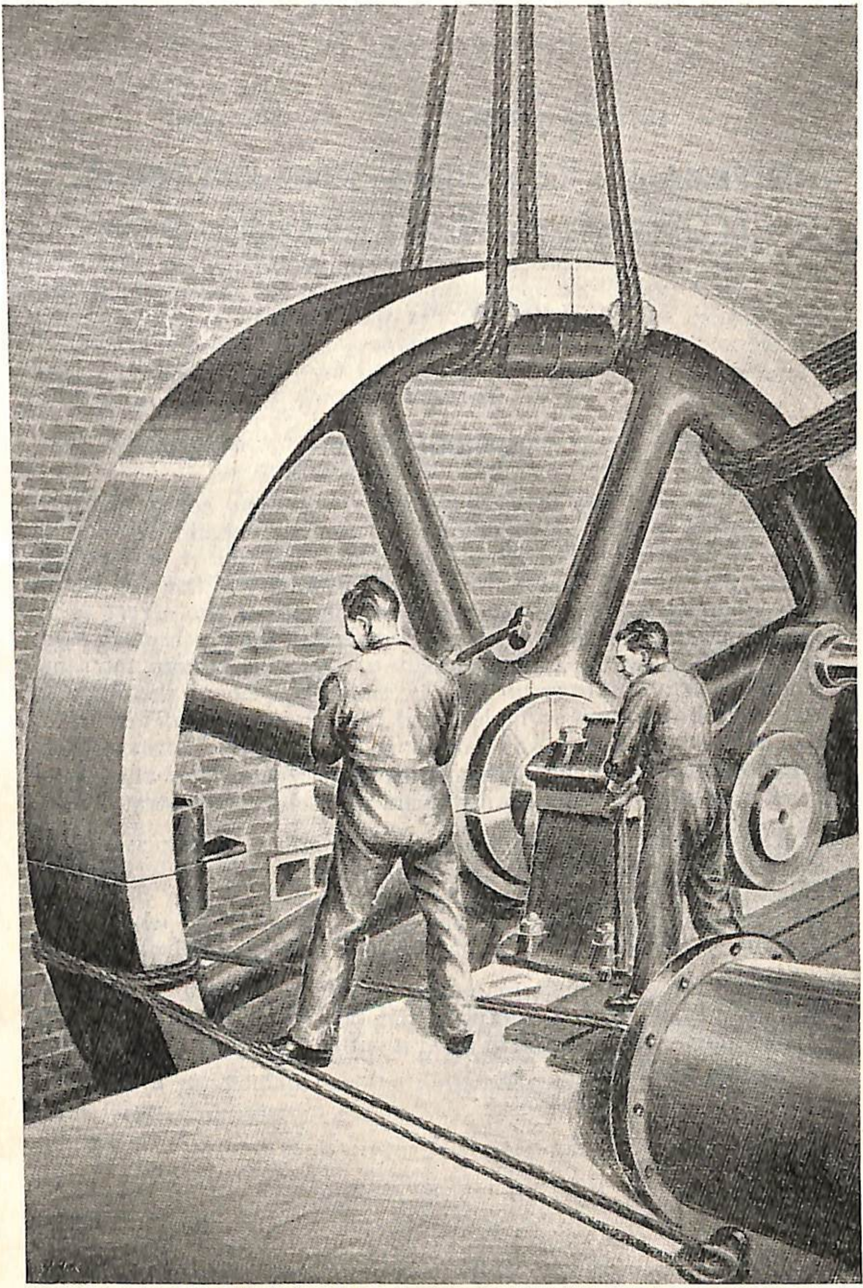

# FREEHAND DRAWING AND PICTORIAL ILLUSTRATION FOR DRAUGHTSMEN.

By W. H. Kerry.

## INTRODUCTION.

There must be very few draughtsmen who have not been called upon at some time or other to construct a freehand drawing of some engineering appliance or machine, either for their own use or as a part of their routine work. The difficulty of the task would vary undoubtedly according to the complexity of the object to be drawn and to the degree of realism required in the finished drawing. In any case, however, the rudimentary principles remain the same whether the ultimate result is to be a simple freehand sketch or an elaborate illustration, complete and correct in every detail. It is the author's intention, as far as space permits, to state these principles and supplement them with hints and devices which have been used with success during years of technical illustration.

It is the author's opinion that drawing office experience is often a hindrance rather than a help to draughtsmen in producing freehand perspective drawings. This is attributable, no doubt, to the constant use of mechanical methods of drawing, which tend to stifle whatever artistic freehand talent is latent in them.

There are, of course, many exceptions to this experience, but that facility in freehand drawing and skill in geometrical drawing do not necessarily go hand in hand is sufficiently obvious to require no special emphasis.

## PREFACE TO THE SECOND EDITION.

It is regretted that since the First Edition was printed in 1940 I have to record the unfortunate death of my collaborator, Mr. E. W. Stott. In the original pamphlet, besides reading over the MSS. and making minor adjustments to the text, Mr. Stott was responsible for the notes on printing processes. These latter have not been included in this edition as it was felt that fuller information is readily available on this subject, and also the space could be more advantageously used in expanding the subjects of cut-away drawing and drawing for reproduction.

In preparing this Second Edition for reprinting, advantage has been taken of the opportunity provided, not only to make minor additions to the text but also to substitute new illustrations and material which it is hoped will enhance the value of the booklet particularly to those younger draughtsmen who have entered the field of drawing since the earlier edition became out of print.

It has been noted with satisfaction that in reviews of the original edition the practical nature of the advice given was stressed, and this has been borne in mind again in the additional matter included in this edition.

The incidence of the war with its dilution of labour in the workshops made necessary in many instances, a somewhat simpler form of illustration than the blueprint and perspective illustration was a ready means to this end. Since that time the creation of a special grade of draughtsman, known as the technical illustrator, has made a knowledge of the subject even more necessary than hitherto. Because of this a new chapter has been added entitled "Cut-away Drawing," in which much greater detail has been given of the principles involved in this class of drawing.

It is necessary to point out that in certain illustrations used in the text a greater reduction in size than is desirable has had to be used. This inevitably results in a thickening-up of the shading lines and is unavoidable as the illustrations were originally drawn for a larger sized page.

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## Chapter I.

## CHOICE OF MATERIALS.

It must be pointed out that while much of the text of this booklet deals with drawing in pencil, all the illustrations printed herein have been prepared with ink for two reasons. Firstly, because the lines and details reproduce with greater clarity in this medium; and secondly, because pencil work can only be reproduced naturally by the half-tone process, which is more expensive than either the zinco or electro processes normally used for the illustration of ink drawings.

Choice of pencil is not a difficult problem, but the lead must be of good quality. 2H or 3H are recommended for all construction lines, as in machine drawing, and for finished work in pencil the intensity of the HB usually should be sufficient for all requirements. While the softer grades of pencil give a more pleasing line, due to the greater contrast with the white paper, this advantage is greatly offset by the ease with which such drawings may be spoiled by inadvertent smudging.

Pencils should be sharpened to fairly long conical points and if used with care do not require frequent sharpening, especially if correct pressure is used.

The deeply incised line of a hard pencil is almost impossible to obliterate with a rubber and the effort, in most cases, will spoil the finished drawing.

The construction lines of any drawing should be executed with the most delicate touch, using little pressure other than the weight of the pencil. The chisel point much favoured by draughtsmen is of little value in freehand work, as it is difficult to draw curved lines without causing gradations in the breadths of them. For lining in with the softer grade of pencil, a fine emery or sandpaper block is essential, as its judicious use will ensure uniform keenness to the point.

Erasers should not be used too frequently in the preparatory pencil stages of ink illustrations. When the work is dry it can be cleaned up effectively with yellow "gum" rubber which will neither damage the surface of the paper nor seriously affect the density of the ink line. Ordinary rubbers, unless very soft and of good quality, not only remove much of the paper surface but some of the ink as well, with the result that the finished product resembles a drawing made on blotting paper.

No attempt is made to suggest a standard choice of nib, as this may be left to the individual taste of the draughtsman, based upon experience. For very fine detail work the choice, however, is restricted to the mapping variety. This pen is obtainable with either a narrow shaft holder or else a fitting for use with the standard broad holder. The latter type is preferable, as the thicker shaft provides a firmer grip and a degree of effective control which is difficult to attain when using the thinner shaft.

For ordinary work the type known as Gillott 303 is favoured by pen-and-ink artists, as with skilful handling it is capable of a great variety of lines of varying width and is sufficiently flexible for even the sharpest curves. The life of an ordinary steel pen is much shortened by the corrosive nature of drawing inks and frequent replacement is necessary unless the pen is cleaned immediately after use.

As far as possible the use of either ruler or ruling pen should be avoided in freehand work as the precision and rigidity of line of mechanical drawing is liable to clash with the easy flow of freehand linework.

Sometimes the use of these methods is unavoidable, as when drawing long straight lines or where mathematical accuracy is desired in curves. In these cases the ruler and ruling pen may be used; for curved work a type of ruling pen with a curved head fitted to a spindle which is free to rotate in the handle will be found convenient.

Paper for freehand and pictorial illustration is largely dependent upon the purpose and ultimate use of the illustrations. If the drawing is to be copied by the normal blue or white print process it will have to be drawn on tracing cloth or tracing paper. The former is suitable only for ruling pen work; the ink flows too quickly from the steel pen and it is extremely difficult to obtain a uniform thin line, and keep blots from appearing. It will not stand up to an eraser and the glass rubber used by some draughtsmen, while removing the mistakes, is apt to discolour the surface of the cloth, and if this does not show in the finished prints it will certainly spoil the appearance of the tracing. The razor blade fitted in a holder is more satisfactory, but here again care is needed not to spoil the surface for subsequent redrawing.

Where copying by this process is necessary it is better to use a good quality tracing paper and preferably one of a non-greasy texture. For reproduction by printing block process or work for permanent record or exhibition, a very good paper for most purposes is Whatman's water-colour sketch board or paper, with hot-rolled surface.

Bristol board, which may be had in various thicknesses, has the ideal surface, but it is expensive and is not advised for general use unless the draughtsman can make his pencil sketch without too great a reliance on an eraser. The glazed surface of this paper or board will not stand rough usage, but on the other hand lines can be produced with an ordinary steel pen of equal brilliance and texture to those drawn with a ruling pen.

Sketch books can be obtained which are made up with transparent white paper having sufficient hardness for satisfactory pen sketching and the added attribute that such paper is ideal for copying purposes.

Some drawing inks of the waterproof variety in common use are not entirely satisfactory for use with a steel pen, as they congeal quickly and leave a drying deposit on the nib. A piece of rag kept handy and used frequently as a pen wiper will counteract the tendency to congeal, but the purchase of best quality ink is strongly recommended. Whichever ink is used, it should always be kept covered when not in use.

Best quality commercial waterproof drawing ink gives a very dense black line which is essential for printing. For delicate ink work, where it is the picture that matters and not the density of line, ordinary good quality black writing ink gives very pleasing results, and shading drawn with a mapping pen can be made sufficiently delicate to represent the shadows due to creases in, say, a white table-cloth.

Colour work is a distinct and separate art and it is not the author's intention to introduce the subject; but before closing this chapter it may not be out of place to mention one or two water-colours of especial value to technical draughtsmen.

Process white is an excellent substitute for erasers and, of course, in contrast to rubbers or razor blades it does not damage the surface of the paper, but its use is limited to drawings for reproduction. It may be bought in convenient sized screwtop bottles and should be applied with a clean brush.

In drawings of machinery for record or exhibition, where appearance is of paramount importance, the finished effect is often enhanced by the application of a wash of Paynes grey over details made of cast-iron and a wash of neutral tint over all the steel components. In a number of cases this gives a most pleasing effect and is indeed a good conventional approximation to the relative colours of cast iron and machined steel parts.

## Chapter II.

## PERSPECTIVE CONSTRUCTION.

In a pamphlet of this nature, intended primarily as a guide to effective freehand drawing, mention must be made of the subject of perspective drawing. While it is true that all perspective drawing is not freehand (the construction being geometrical), it is also true that all naturalistic drawing must have some basis in perspective, even though it is not built up on the correct mechanical perspective construction.

It is not intended to treat the subject exhaustively, as many books have been written exclusively on this subject and are available at most libraries. The Association also publish a very excellent pamphlet which will amply repay further study.* There are three main methods of projection used in drawing—isometric, orthographic and perspective. Of these, perspective drawing alone shows an object as it really appears to the eye of the beholder. This is due to account being taken of the apparent convergence of parallel lines at an angle to the line of sight. Thus, the longer the lines the more nearly do they appear to approach one another until, as we were taught at school, they meet at the limit—infinity. No drawing we shall be called upon to make will need that amount of convergence, but it is a fundamental fact that however simple the object appears the drawing will never appear exactly right if due regard is not paid to this principle of vanishing points.

It follows, therefore, that if an object such as a cube is viewed at right angles to one of its faces, but slightly above its top edge, the outer lines of the top surface will appear to converge (Fig. 1).

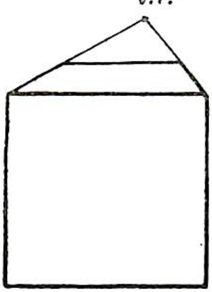

**Fig. 1.**

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* *Perspective Drawing for Draughtsmen*, by W. Sellar.

The magnitude of this angle of convergence will depend on the size of cube, angle of vision, distance of viewpoint and, in this case, there is only one vanishing point. If, however, the cube is turned round or the angle of sight altered so that it is now viewed as in Fig. 2, it will be found that not only are there converging lines on all four edges of the top face, but also on the two vertical faces now visible. In this case there are two vanishing points, one to the left of the sight line and one at an equal distance to the right (if the cube is viewed symmetrically). From a strictly accurate point of view there is actually a third vanishing point in this view because, as the cube is being viewed from above, the vertical lines of the two vertical faces appear to converge even though the amount of such convergence is almost negligible. Because of the smallness of this angle it is usual to ignore this effect unless the drawing is of some high building or other tall object, when its effect is far from negligible.

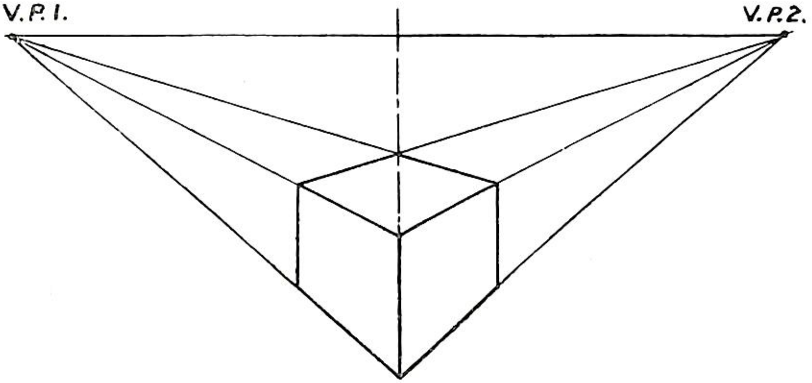
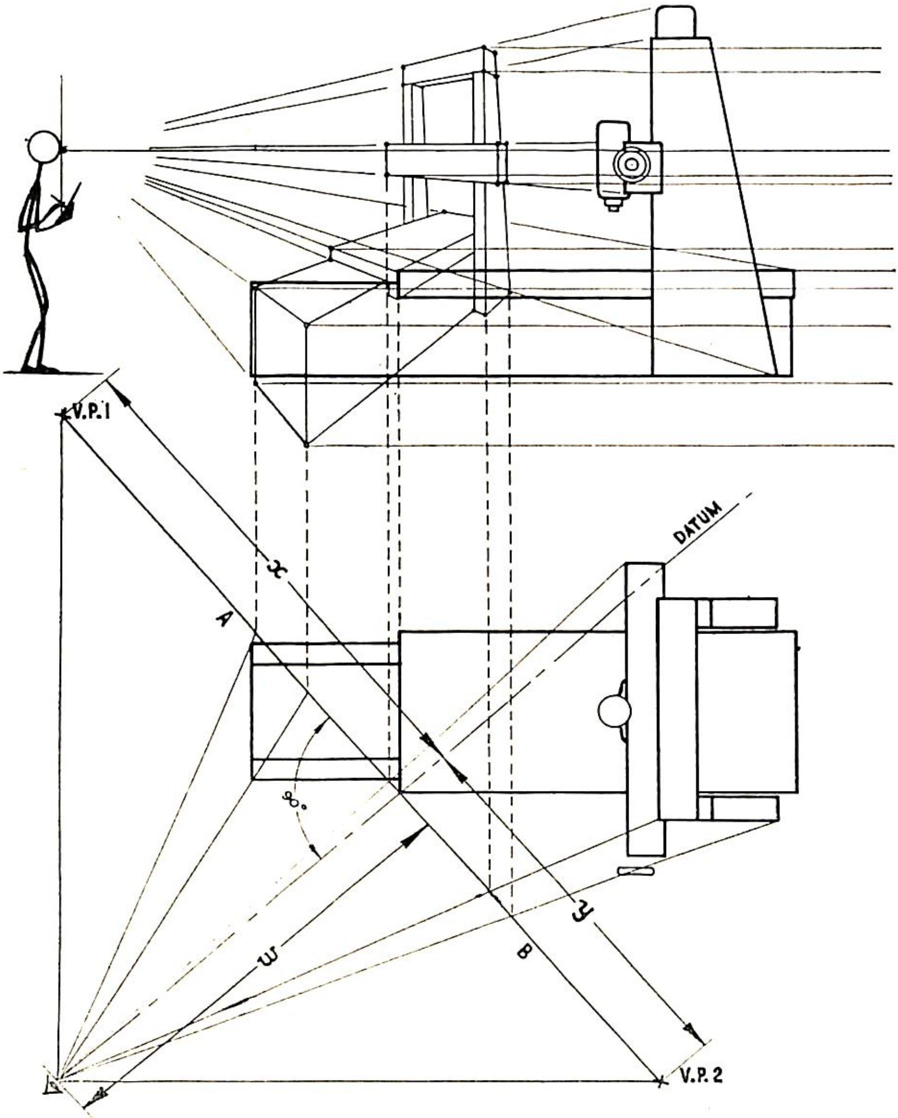


Fig. 2.

There are many people, even among experienced draughtsmen, who apparently doubt the existence of this third vanishing point. A study of photographs of tall towers or sky-scrapers, particularly from a high viewpoint, will help to make this point clear.

The first stage in perspective construction is to draw the elevation and plan in correct relation in the middle of a fairly large sheet of paper and preferably simplified as in the example Fig. 3.

This drawn, the viewpoint must be decided in both plan and elevation. In elevation this is usually a simple matter, provided a freak view such as a "bird's eye" or "worm's eye" is not contemplated, because the draughtsman would be presumed standing and his eye would be at its normal level, somewhere in the neighbourhood of 5 feet or 5 feet 6 inches.


V.P.1
V.P.2
DATUM
A
B
x
y
w
90°

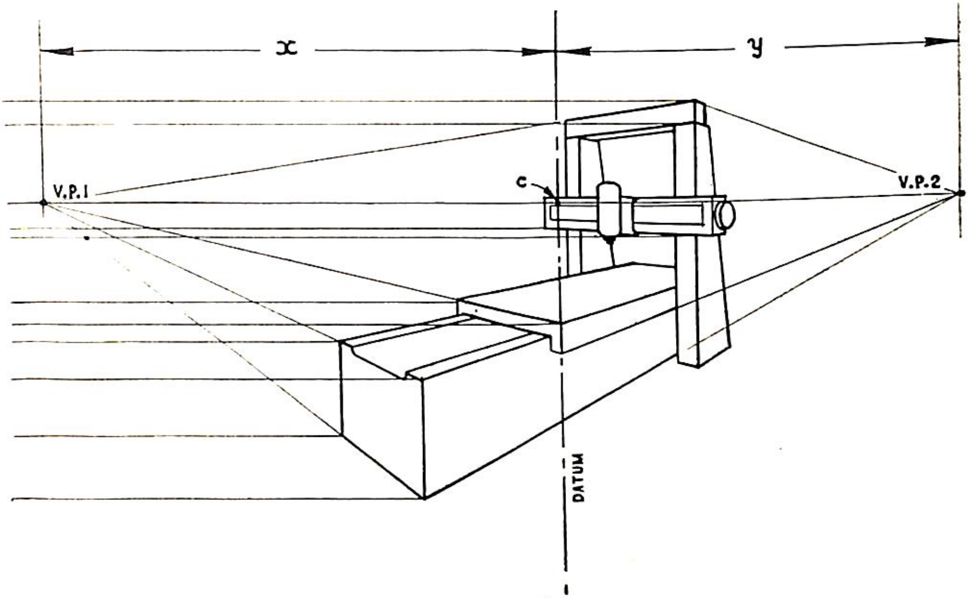


**Fig. 3.**

The illustration above shows the completed perspective picture of a Planing Machine. It will be obvious that the number of construction lines shown is less than would be required for actual projection-

The difficulty arises in the plan and deciding the viewpoint is the test of the usefulness or otherwise of correct perspective construction. If a selected viewpoint is too close, the object would appear grotesque, like the photographs we have seen of the gargantuan feet and small body, the result of placing a camera too near the feet. If, on the other hand, the viewpoint is too far away, the essential details will appear small and remote.

The choice is not an easy one and will come only through experience, although fortunately there exists a rough rule which may help towards solving the problem, of which more details will be given later on.

Having settled the viewpoint in plan and elevation, a line is drawn in plan from the viewpoint to a point as near as possible to the centre of the mass forming the plan, and this is our datum line.

Radial lines must then be drawn from each of the two viewpoints to all the essential points of the plan and elevation respectively.

The extreme radial lines thus drawn in each case enclose what is known as the cone of vision and here is the explanation of the rough rule already mentioned. It has been found by experience that best results will be obtained without distortion if this angle, both in plan and elevation, enclosing all the details to be illustrated, is kept within 60°.

The next thing to consider is the size of the picture.

It should be obvious to the reader by now, that the measurements of the picture are in some way connected with the cone of vision—the picture size is in fact determined by the position in which the trace of a vertical plane is drawn in plan, called picture plane, cutting the datum line at right angles (see AB in Fig. 3).

Its position is purely an arbitrary one having regard, however, to the desired size of picture, a narrow plane giving a narrow picture and *vice versa*.

A convention often adopted locates the picture plane at the point of the object nearest the viewer, and in this case vertical dimensions at this point in the finished drawing will be of the same magnitude as those initially drawn in elevation. This method furnishes a useful key to the scale of the projected drawing, a difficult thing to conjecture in the normal way.

The points of intersection of the radial lines in plan with the picture plane are next projected up to the corresponding radial lines in elevation, and the points obtained marked with dots, as shown in Fig. 3. If these points are joined up in correct order, to follow the outlines of the object, the resultant figure will appear as a rather squashed version of the final drawing. The reason for this is apparent when it is remembered that, in this view, the picture plane is being viewed obliquely and not at right angles ;

therefore, only vertical lines are of correct length. To complete the construction, another vertical datum is drawn some distance to the right hand of the elevation and lines from the dots previously obtained are projected horizontally across the paper.

Measurements with dividers are now taken from the origin (the point of intersection of the datum in plan with the picture plane) for each point previously projected upwards and each dimension now set off right or left of the new datum and on its appropriate line. The construction sounds more involved than it really is, but reference to Fig. 3 will, it is hoped, make the method clear. A word of warning seems advisable. Keep the plan and elevation drawing to the very minimum of essential lines, otherwise the number of construction lines will make projection difficult, if not almost impossible. To complete the perspective picture, join up the points in correct order.

It will be noted that so far in this construction no mention has been made of vanishing points, the location of which is important.

Consider the object drawn in Fig. 3. The vanishing points for two vertical planes at right angles to one another—as in the case of the cube mentioned earlier—must be determined. For this purpose it is necessary first to extend in the plan the picture plane on either side of the origin O. Then through the viewpoint, also in plan, draw a vertical line parallel to one vertical plane and then another horizontal line at right angles to the first and parallel to the second plane. Where these lines cut the picture plane are the two vanishing points in plan.

To transfer these points to the perspective picture is a simple matter, since it is known that all horizontal lines in the object converge to the horizon line in elevation. Therefore, continue the horizon line across in elevation on a level with the point of sight and set off on it, from the vertical datum already drawn, the dimension $x$ to the left and $y$ to the right. Points $VP_1$ and $VP_2$ are the vanishing points, and it may be useful in construction to plot these first, as by making good use of them, certain of the construction lines become unnecessary. Thus, in the finished drawing, it will be found that all lines in one plane, if continued, meet at one vanishing point and conversely with the other and it will be obvious that, having plotted one end of a line in perspective, the other end and direction of it may be found readily by a line drawn to the vanishing point and cutting the projected horizontals. The tedium of transferring *all* widths from the picture plane is thus avoided.

The student may well ask why perspective construction is advocated in a treatise mainly concerned with freehand drawing. Experience has shown that while some people have a natural flair for artistic expression and are capable of freehand perspective without working from a geometrical basis, others, by far the larger proportion, are not so fortunate as to possess this gift. This chapter, therefore, is intended to show that the basis of all freehand drawing is perspective, and to illustrate a method for correct perspective construction.

When draughtsmen are called upon to construct a drawing from the lineal dimensions of blue prints, unless they have the visual power of the artist, the job is next to impossible without the aid of perspective construction.

In such a case a useful method is to simplify the blue prints into simple block masses, using to the full, where possible, the easy projection properties of cubical and rectangular masses and constructing a true perspective picture, as in the example described above. The resolution back to the correct form of the object will be a comparatively simple matter and all curves and small details can then be drawn in freehand. It will be found also that, if only a small portion of the drawing is constructed in this way, it will furnish an excellent framework on which to build the additional parts of the structure, since the vanishing points will be already in position.

It sometimes happens that on completion of a correctly constructed perspective picture one is aware of a certain oddness about its appearance. This can be explained usually by the fact that the viewpoint is wrongly placed, resulting in a distorted image. It should be borne in mind, however, that the picture is strictly correct only when viewed with one eye from one certain point. This point in space is determined geometrically by the scale dimensions used in the original selection of the viewpoint. Thus in Fig. 3, the correct position for viewing is found by measuring distance $w$ vertically above the point C. If the reader cares to try this experiment he will probably be surprised at the difference of aspect due to correct viewing.

## Chapter III.

## DEVELOPMENT FROM ROUGH SKETCHES.

Before proceeding to consider actual examples of freehand drawing and methods of procedure, it might be worth while to see to what extent freehand and pictorial work may be required of the draughtsman.

(1) The most common example of such work, and one which must at some time or other concern all draughtsmen, is the sketching of details of machinery and appliances from the finished products. Usually these are of a simple nature and are intended as an aid to memory rather than as drawings to be kept in permanent official record. The draughtsman's sketchbook contains many examples of such work.

(2) Drawings of finished products sometimes must be prepared from blue prints and frequently before the time when the designs have reached the production stage.

(3) The Patent Office prefers perspective illustration to line drawings, probably because they leave less to the imagination, and have the added advantage that they are intelligible alike to the technician and the layman.

(4) Pictorial illustration with rather more elaboration and finish, intended for reproduction, and a class of work which appears to have increased in volume in recent years.

(5) Exhibition work for trade shows, sale rooms and foreign agencies.

The basis of all freehand picture drawing is the representation of the cube and cylinder in perspective. With the ability to draw these accurately in any position, comes the facility required and appreciation of the rules of perspective. They are both simple geometric forms and the correct drawing of them, separately, or in combination with each other, represents most of the problems likely to arise in freehand perspective.

In freehand work there is no guide to accuracy except the eye and commonsense in apportioning the dimensions of the objects represented. It is, therefore, guesswork based on knowledge, with the eye acting as arbiter. Most people will agree that however imperfect the human eye may be optically, it does give a ready check on distorted objects.

In this connection the artist may have naturally a keener perception of error, but if a square or circle is drawn in freehand perspective it should be apparent, to even the untrained eye, whether the object actually looks square or circular.

It has been shown that the cube in perspective has converging lines along the edges of its faces at an angle to the picture plane ; * the effect of perspective on the circle will now be considered. Fig. 4 illustrates the construction of a circle inside a projected square, where it will become obvious at once that the perspective circle is an ellipse. It has this peculiarity, however, that if the diagonals are drawn, the point of intersection will represent the centre of the circle in perspective, and obviously this point will be nearer the back than the front line of the square. Thus the horizontal diameter of the circle when projected *does not* coincide with the major axis of the ellipse, and, therefore, does not bisect the circle in perspective.

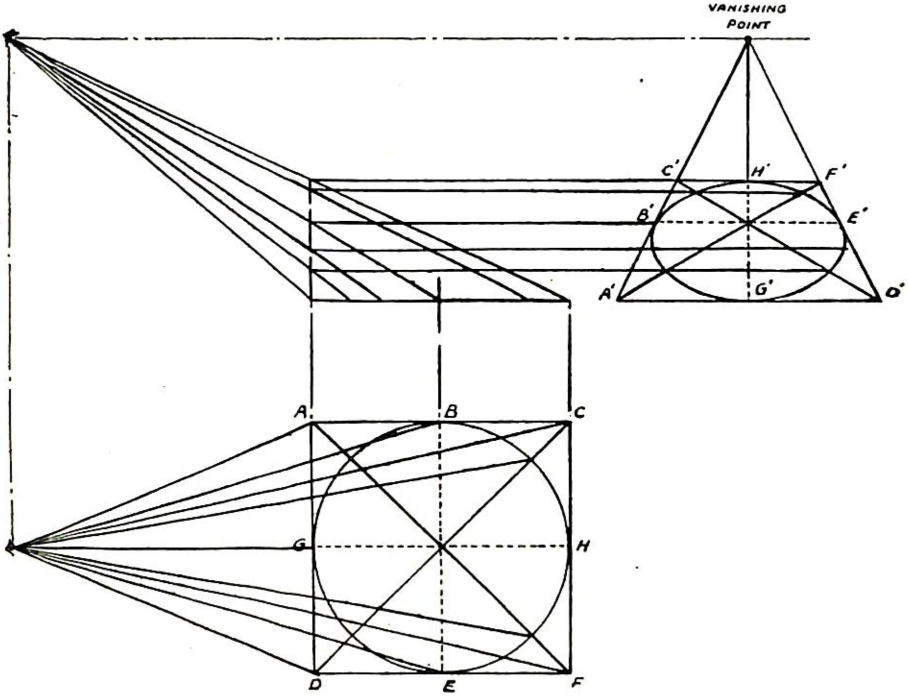


Fig. 4.

In, for instance, a drawing of a cylinder in perspective, this would merely have the effect of throwing back the centre line, but unless the cylinder was very large or the viewpoint close, the effect would be small enough to be discounted. It is surprising how many people, when drawing a cylinder inclined at an angle to the horizontal show the cylinder end either as in Fig. 5 (*a*) or else, and more correctly, as in Fig. 5 (*b*). In one case examined all the shaft ends on a machine were drawn with their axes vertical, with the result that the machine appeared to be jacked up at the back only, Fig. 5 (*c*). Cylinder ends should be constructed in the following manner :—

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* In perspective construction lines parallel to the picture plane are drawn parallel when projected. No allowance, usually, is made for the slight deviation which would occur if the lines were of any great length.

First, draw the centre line of the cylinder at the correct angle and then a line at right angles across it, representing the major axis. Mark off the minor axis on the centre line of the cylinder and draw an ellipse. It is not advisable to use a perspective construction for this ellipse, but to draw freehand in pencil any ellipse on those axes and allow the eye to judge whether the ratio of minor to major axis is correct for that particular viewpoint. It is well worth while not only to practise freehand drawing of varying shaped ellipses, but to embroider these sketches by converting them into cylinders inclined at various angles. In connection with this ratio of minor to major axis in drawing cylinders, the

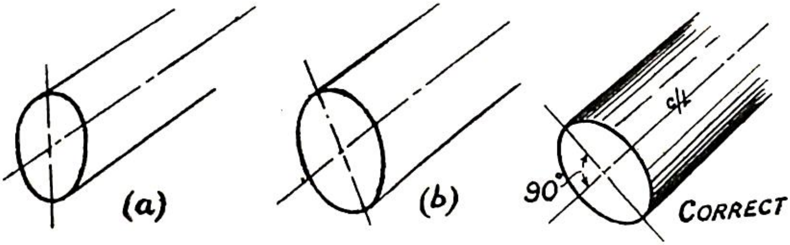

Fig. 5.

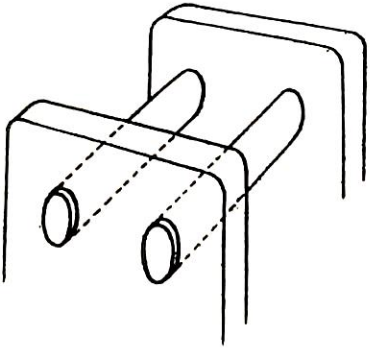

Fig. 5 (c).

obliquity of the two end faces must be considered. Reference to Fig. 6 will make this point clear; ellipse B will have a proportionately longer minor axis than ellipse A, because each end face converges to VP$_1$.

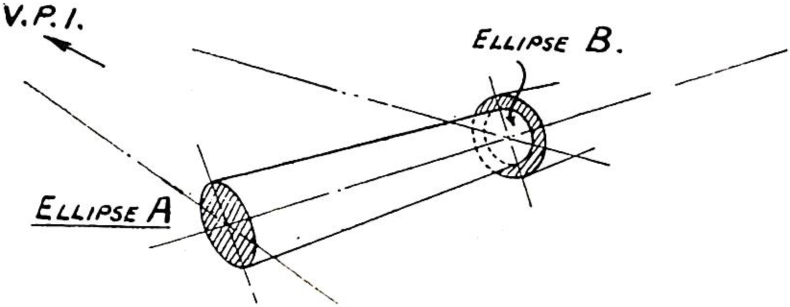

Fig. 6.

If a section of shafting is substituted for the cylinder and shown carrying such things as pulleys, couplings, etc., the procedure adopted is the same as in the case of the cylinder. As an illustration of this, take a view of an overhead shaft seen from below.

As in machine drawing, the centre line of the shaft is drawn first at the correct angle, that is, tilted downwards towards a vanishing point which is on a level with the eyes. Let AB, Fig. 7, represent such a line and C the vanishing point. At the left-hand end of shaft, draw an ellipse (as previously described) to represent the shaft diameter and join ends of major axis to vanishing point. At some point D draw another line EF at right angles to AB and set off the pulley diameter, approximately to scale, to correspond with the major axis and in freehand construct another ellipse. Set off along the centre line from EF, a distance about equal to the width of the pulley face and draw GH parallel to EF, and on it sketch an identical ellipse. The pulley boss can be put in, using smaller ellipses, on the same lines EF and GH. Then draw in the pulley spokes to give a realistic appearance. Other pulleys or couplings can be added, using similar constructions. There is this to remember, however; as these ellipses are constructed further along the shaft to the right, the more nearly do they approximate to circles; also equal original measurements, such as pulley widths, get successively smaller. If it is required to add a bearing and shaft support, the direction of the upper face of the latter is obtained by drawing a line from a point a little below the shaft to the vanishing point on the left. (It will be remembered that the two vanishing points each lie on a horizontal line at eye level). In this sketch, although it has been drawn largely freehand, some construction lines have also been used. It will be

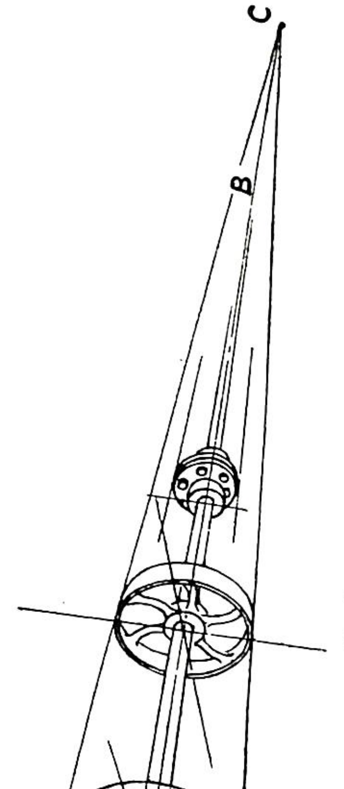

Fig. 7.

found that proficiency comes with practice until a stage is reached when many of these lines will become superfluous.

The experienced freehand draughtsman rarely plots vanishing points or constructs ellipses. Proportion, too, rarely calls for the use of a scale, unless great precision is necessary ; but such methods are not recommended for the beginner, depending as they do on experience, and above all on a thorough grasp of the underlying principles of perspective.

So far only the principle of the circle in perspective has been used to construct a realistic freehand picture of a line of shafting. If to this principle is coupled the equally important treatment of the cube in perspective, it will be found that with this added knowledge sufficient data is available for drawing in perspective most objects likely to be studied by the mechanical engineering draughtsman, as most mechanical objects for this purpose can be resolved geometrically into such forms as the cube and cylinder or variations of both.

The construction of the conic form from the point of view of drawing differs little from that of the cylinder, and the cube is but a special case of the rectangular prism.

Consideration will now be given to the drawing of a vertical milling machine requiring more elaborate construction, and the use of geometrical forms in addition to the cylinder. A glance at Fig. 8 (*b*) will convince the reader that the traversing machine table in itself forms a rectangular prism and also that the base on which it is supported and slides needs little resolution from its present shape into the same rectangular block form. The supporting column and cutter spindle, which form the upper portion, are situate more or less symmetrically about their respective centre lines. To commence, set out the forms and centre lines required, starting for convenience with the machine table and ignoring the *exact* position of vanishing points. Fig. 8 (*a*).

The top surface of this machine table may be regarded as a sort of basic rectangle, which, once positioned, determines, to a large extent, the direction of most other lines (other than verticals) in the drawing. Should it be necessary to make alterations in the viewpoint, the transposition should be carried out at this stage. Raising or lowering the viewpoint determines the amount of the upper surface seen and either would affect the inclination of the lines forming the basic rectangle.

Care is needed, therefore, in the layout of this rectangle in perspective, particularly with regard to the angles marked A and A, Fig. 8 (*a*), and also to the ratio of length to breadth.

In most subjects for draughtsmen's freehand drawing there is some feature which can be taken as a basis for the drawing and its correct perspective drawn in by eye. It will form a sort of foundation stone around which the picture is built and, because

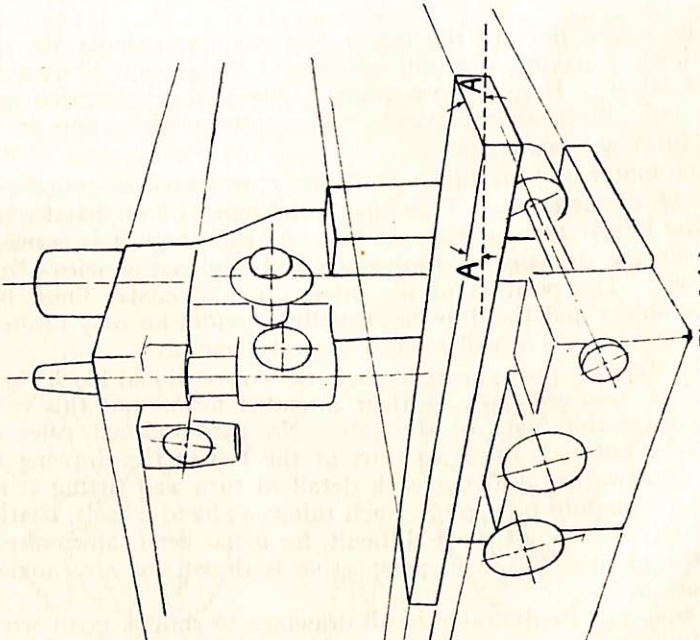

Fig. 8 (a).

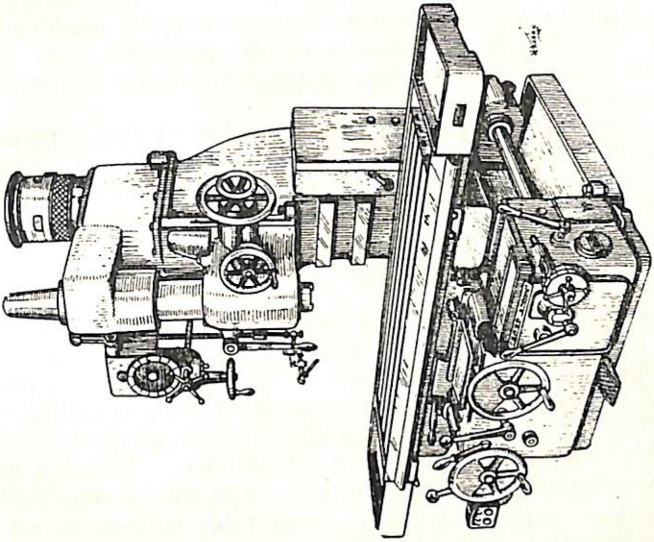

Fig. 8 (b).

of this, especial care must be taken in drawing this feature. In the case of Fig. 8 (*a*) this feature is the rectangular machine table, and it is preferable to choose a regular geometric form, as the eye will respond more readily to any inaccuracies in perspective representation.

The recession of parallel lines in either of the directions at right angles should be studied although, as mentioned previously, exact vanishing points need not be plotted. It will be found usually that errors, due to the convergence of parallel lines in perspective, will be more apparent when the construction sketch is completed than during construction and amendments can then be made.

Frequently it happens that vanishing points in a drawing are so far away as to be off the paper, which necessitates using very large sheets; this is one reason why they are so often omitted. Partial guidance to the amount of taper may be obtained by extending one or two of the parallel lines in perspective beyond their true lengths towards the vanishing point. Thus the placing of intermediate lines at their correct angles will be simplified.

The base supporting the machine table is then drawn as a rectangular block, and then the upright column at the rear of the table.

The centre lines of the motor and machine spindle are then added, after making a careful estimate of the amount of overhang of the latter. Here it is necessary to use thin construction lines, since only block shapes which will require modification to the final form are being drawn.

The motor and machine spindle are represented as cylinders of different diameters and then the centre lines of all hand-wheels and the horizontal shafts are added. At this stage it is necessary to check the drawing for proportion and any inaccuracies of perspective. The position of the intersection of centre lines, both on the object and the drawing, usually provides an easy means of checking and others will readily suggest themselves.

The drawing proved satisfactory, the conventional block shapes should be resolved back to their intended forms and this is the most interesting part of the job. No hard-and-fast rules can be given, but it is usual to start at the top of the drawing and work downwards, studying each detail in turn and fitting it into the shape already prepared. Such things as hand-wheels, bearings and shafts should not prove difficult, for it has been shown already how the circular shape in perspective is drawn for any angle of inclination.

It may not be desirable in all drawings to show a great wealth of detail, but in any case instruction will be given in the next chapter as to the methods of drawing some of the more common machine details.

## Chapter IV.

# TREATMENT OF COMMON MACHINE DETAILS.

The last chapter dealt with the development of the sketch of a machine using conventional block shapes, which are later modified in detail to the form of the object drawn, and it now remains to study the method of detailing the various machine parts likely to be met in practice.

The spoked pulley is widely used on line shafting and is also an integral part of certain classes of machinery. In Chapter III the setting out of the pulley boss and rim is described and there remain only the spokes. If there are six spokes in the pulley, three equally spaced centre lines are required across the face of the pulley.

It will be found convenient to take the major axis as one of them and estimate the perspective spacing of the other two by eye. If the spokes are of the straight or slightly tapered variety, completion of the pulley is a simple matter. In the case of the more usual curved variety, first draw freehand arcs along each centre line as in Fig. 9, and after allowing a moderate thickness for the spokes, follow with a second set of arcs differing from the first in that the ends are of opposite curvature. With practice, an excellent impression of a spoked pulley wheel may be evolved. (See Fig. 9).

If two adjacent pulleys are required to be drawn, as for fast and loose pulleys, a suggestion of the spokes of the more remote pulley will be the only indication necessary. (See Fig. 10).

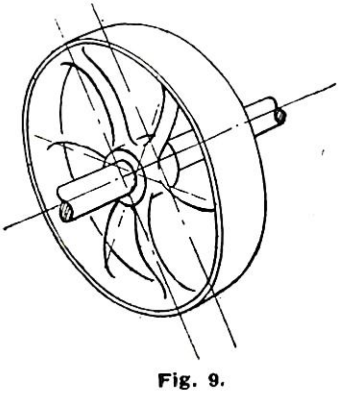

Fig. 9.

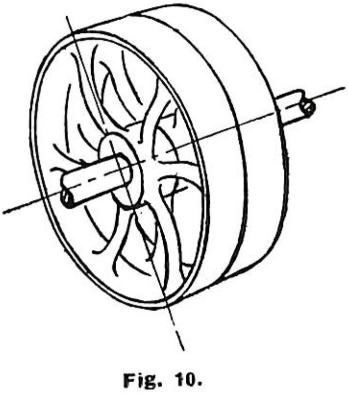

Fig. 10.

The most common item in general engineering use is probably the nut and bolt, and yet one sees worse representations of them in freehand drawing than of almost any other mechanical detail.

Having drawn the centre line and shank, a good method of procedure is to represent the bolt head with two ellipses, the upper one (see Fig. 11) with a slightly smaller major axis (the major axis of the larger ellipse is approximately twice the diameter of the shank). Lines A, B, C and D are then drawn parallel to the shank and the bolt head completed by sketching in the arcs E, F and G, and the lines H, I and J. It will be seen how the chamfer on the bolt head has been made apparent by using a smaller ellipse for the upper surface. In the case of nuts, the procedure of course is similar, and if either the bolt head or nut is viewed across the flat from one of the corners, only two faces instead of the three shown will be visible.

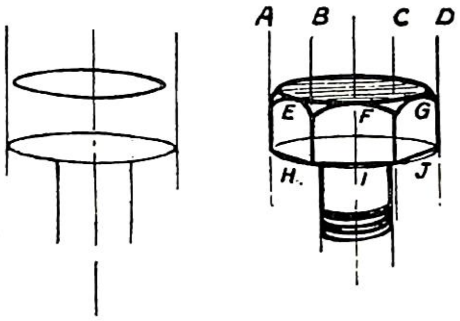

**Fig. 11.**

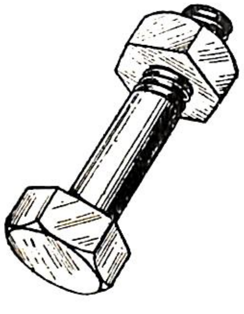

**Fig. 12**

Threads of the Whitworth type can be shown as a succession of ellipses (see Fig. 12), but with their major axes tilted slightly to correspond with the pitch of the screw. The smaller intermediate ellipses can be shown with a thicker line to represent the root of the thread.

The "square thread," especially if large, needs more careful construction because of its shape, and in this case, its spiral form will be more evident (see Fig. 13). The elliptical method is again used in the construction, but the spiral is suggested by flattening of the ellipse on one side (see A in Fig. 13). The threads illustrated are all "right-handed," but for "left-handed" threads, the pitch angle, of course, is inclined in the opposite direction. Constructions for double and triple start threads are not illustrated, since the reader, being technically minded, will know how to amend the construction for varying pitch angles.

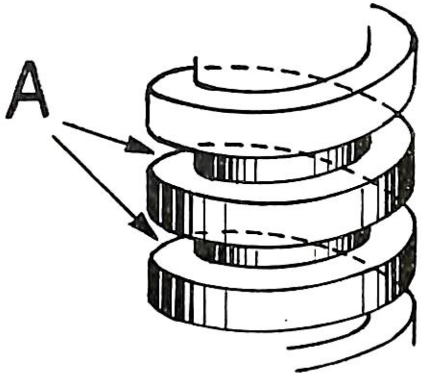

Fig. 13.

The worm and worm wheel can be resolved into two block shapes, the solid disc and cylinder, Fig. 14, with their respective centre lines at right angles to one another. The wheel must be shown partially sunk into the cylinder and not just resting on it, and care must be used in shaping the ellipse representing the wheel; this will depend on the angle of sight. The worm proper is then drawn along the visible portion of the cylinder using a similar construction to that for the square thread. Next, the worm wheel teeth are shown around its periphery and the form of each tooth shown by curved lines drawn across the width of the worm wheel. It will be noticed in Fig. 14 how the curvature and direction of

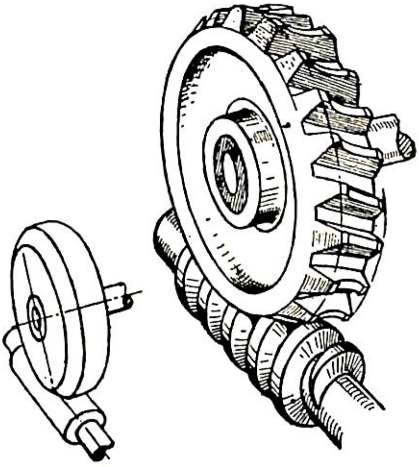

Fig. 14.

these lines vary. It now remains but to terminate these lines with a suggestion of the tooth form, and to add details of shaft ends, etc., as required.

The "bevel gear" is another form of gearing that is commonly used, the construction of which involves the same principles as hitherto. Fig. 15 shows also the block form and needs little comment. Setting out the teeth inclinations can be facilitated by locating the apex of the cone of which the wheel is a part, and joining to each tooth. Remember also that the tooth spacing becomes successively less as it recedes from the centre line on either side.

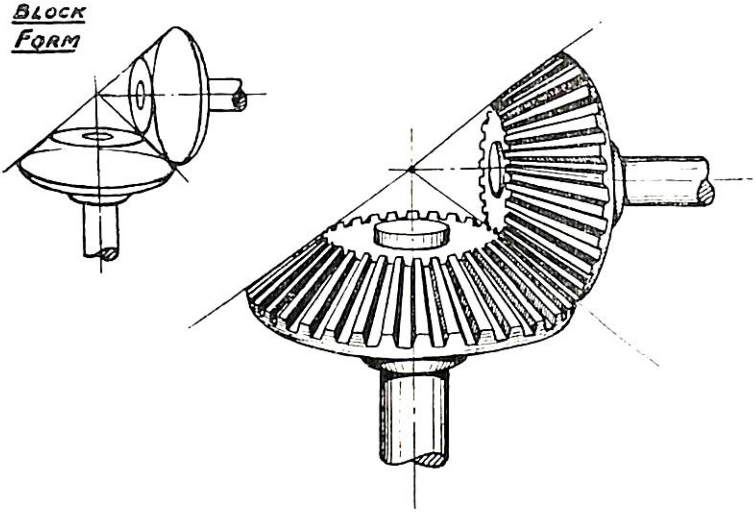

Fig. 15.

Instruction in the drawing of "spiral springs" is difficult to give and presupposes that the reader can draw a spiral. Practice in freehand drawing of the ellipse is a great help, for the spiral form is, in some respects, a succession of incomplete ellipses. If one commences drawing a freehand ellipse and at the same time moves the pencil down the paper at a uniform rate whilst still drawing, the outcome is a spiral. It must be realised, however, that in drawing the spiral, its pitch would depend on the type of spring it was desired to illustrate, and whether it was in compression or tension. Fig. 16 is a drawing of a spring under tension and shows how the addition of a second line to the initial spiral is all that is needed to give realism.

"Handwheels" are in use as a standard fitting on most machines and usually have a rim that is circular in section. The centre

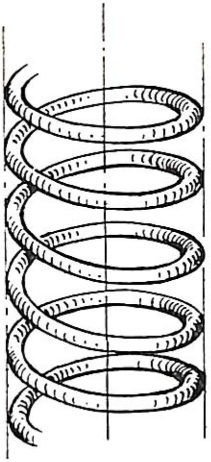

Fig. 16.

line of the spindle is drawn and at the position of the handwheel along it, an ellipse is sketched to represent the outer periphery of the wheel (see Fig. 17). On the same axis and symmetrical to the first ellipse others are drawn to represent the inner circle of the rim, the outer circle of the handwheel boss, and the inner shaft diameter. A portion of another ellipse is needed now to give thickness to the boss and the spokes can then be inserted. Remember that spokes usually intersect the boss half-way across its width and carry a fillet of metal at the junction. The centre

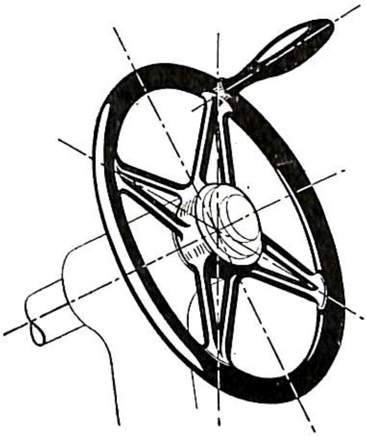

Fig. 17.

line of the handle proper can now be added. Its position is usually at the junction of one of the spokes and passes through the centre of the rim, approximately parallel to the spindle ; on it the handle shape is disposed symmetrically. The type of handwheel in which the rim and boss do not lie in the same plane presents no difficulties, the inner ellipses being moved further along the centre line and the spokes curved to join the rim to the boss.

In most of the drawings in this chapter a rather similar viewpoint for each object portrayed has been assumed and it is taken for granted that the reader can make the necessary corrections for any other viewpoint that may be required. Reference to Chapter III., which deals with the circle in perspective, will make the process clearer, should this be necessary.

A few general remarks on freehand line work may not be out of place here.

Lines drawn by the artist have a different significance from the abstract geometric lines drawn mechanically by the technical draughtsman. The former are intended to express much more than the boundaries of shapes, in that they are drawn with the desire to express feeling or emotion. The artist achieves this effect by subtle variations in the pressure applied to his pen, brush or pencil, as a contrast to the uniformity of the mechanically drawn line.

This book is concerned more with prosaic and utilitarian objects than with artistic ones, but even so lines can and do have quality. The bold decisive line of either pen or pencil is the ideal, but attention to small details found necessary in some cases prevents the fulfilment of this ideal.

In pen work the ink line represents finality and, therefore, great care and consideration must be given to its execution, otherwise the difficult task of erasing mistakes will have to be undertaken at a great risk of spoiling hours of work. The pencil, on the other hand, allows much more freedom of expression, and erasures, except on paper with sensitive surfaces, will not mar the finished product.

## Chapter V.

## CONVENTIONAL TREATMENT.

It will be obvious to the discerning reader that experience in the medium of freehand drawing over a number of years will bring with it more or less standardised or conventional methods of drawing certain materials and appliances. It is intended in this chapter to illustrate the method applied to a few materials or appliances in frequent use.

First, the electric motor. Fig. 18 shows an electric motor in simplified form, but retaining sufficient characteristics to make identification certain. It has the added advantage that it can be drawn freehand in accordance with the simple principles already discussed, viz., the circle and square in perspective, and so needs little elaboration.

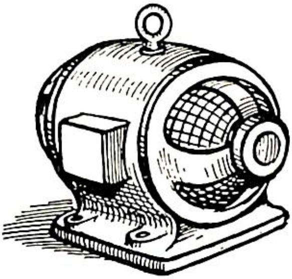

**Fig. 18.**

Should it be necessary to draw a large area of wire mesh, expanded metal or punched strip, the task may prove irksome, but time may be saved by sketching a portion only in some detail, and suggesting the rest.

A similar conventional method is applied sometimes to indicate brickwork by showing a few bricks only, and in this case it will be found that the extra effort of drawing double lines for the mortar bond instead of the more usual single line will be amply repaid by the resultant realism in the picture. This power of suggestion can be of great service to draughtsmen, and if a sketch, for example, is required of a machine used in a certain process or industry, a little ingenuity in suggestion drawing will help to give "atmosphere" to the picture.

In a drawing of a riveted structure, the rivets are details only and therefore a crescent, suggestive of the shadow on the rivet head, usually is sufficient to give a realistic appearance (see Fig. 19).

The webs in rolled steel sections, usually of the H, Angle or Channel type, always have a radius or fillet where they meet the flanges, and it is better to denote these by short curved lines suggestive of the radius than by a straight line along the length of the section (see Fig. 19).

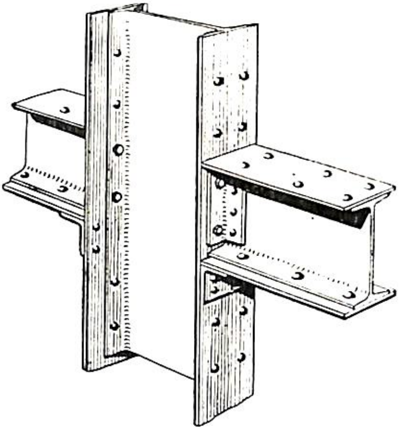

**Fig. 19.**

The above example calls to mind other and frequent cases, particularly in machine design, where the junction of surfaces is accomplished by "radiusing." The same method of suggestion is used here, and it will be found that even though shading is not used, the change of direction of the surface is made evident.

It sometimes happens that a drawing is required to show a number of identical features that would involve much time and tedium in construction. Fig. 20 shows an example of such work and the method of procedure followed to overcome this repetition of detail. One or two features are shown complete as to detail, and a sufficient number are suggested to convince the person looking at the drawing that they are continued all round the surface.

In the representation of wood in drawing, an arbitrary grain is used that generally has little relation to the particular species of wood. End grain is shown by curved lines more or less concentric to one another and intersected by a few straight lines arranged radially. In Fig. 21 the side face is distinguished from the upper face by drawing the grain lines thicker, so making shading superfluous.

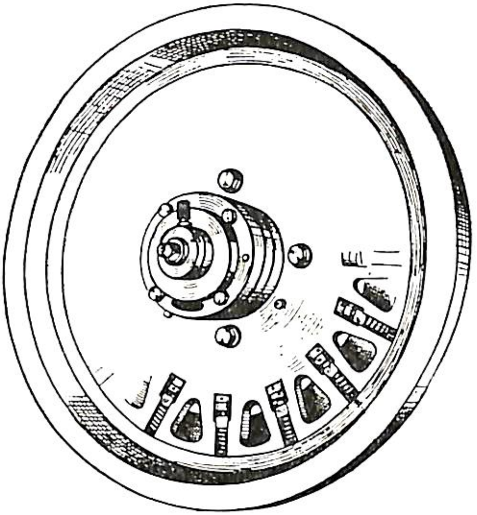

Fig. 20.

Ropes, whether of fibre or wire construction, are shown as a succession of S-shaped curves (see Fig. 22). If the rope is large enough in diameter to allow of detailed freehand treatment, slightly wavy lines parallel to the axis can be drawn to represent the fibres or wires as the case may be.

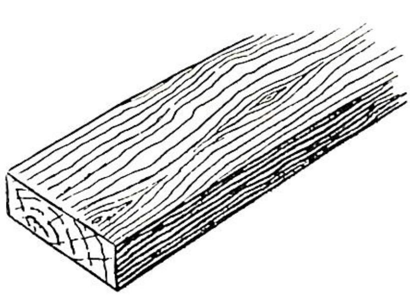

Fig. 21.

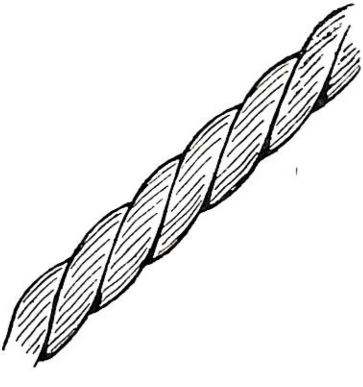

Fig. 22.

In drawing chains, either of the two diagrammatic arrangements used by draughtsmen can be employed (see Fig. 23 (*a*) ), or else, and more realistically, the chain can be drawn in link by link, Fig. 23 (*b*). If the latter course is adopted, care must be taken to show that each successive link is in a plane at right angles to the preceding link, otherwise the result will not repay the extra effort involved.

This attempt at realism in chain illustration will be enhanced if each link has a conventional shadow drawn on it (see Fig. 23 (*b*) ).

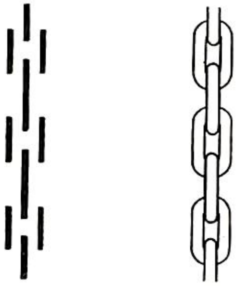

**Fig. 23 (a).**

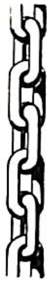

**Fig. 23 (b).**

## Chapter VI.

## CUT-AWAY DRAWING.

In recent years, and particularly during and since the war, much greater use has been made of the cut-away method of illustration. Its use, during the war particularly, served to make plain to semi-skilled workers, unable to read complicated blue prints, the workings of intricate mechanisms and even, in some cases, replaced the blue print on production work.

So important has the subject become that specialisation has meant the creation of a special grade of draughtsman known as the technical illustrator. The method has much to commend it, in spite of the abuse of artistic licence involved, for it enables one to see, in a single picture, details that would normally be hidden by structure, and which would require many drawings to make their purpose clear.

For the cut-away to be used to the best advantage discretion and knowledge is needed in the selection of the viewpoint and skill in determining just where to section the parts. No hard and fast rules for this sectioning can be laid down and sometimes even the ordinary rules of perspective drawing are waived.

In the case of the more complicated type of illustration it is almost imperative to prepare rough sketches in the first instance in order to make sure that the choice of viewpoint is correct and that all the features to be shown can indeed be seen. It is very distressing to proceed with a finished drawing and then to find that because of a wrong choice of viewpoint it is impossible to reveal an important feature, but the mistake is an easy one to make.

Whilst it is difficult to lay down general rules for this type of drawing which may vary in complexity from the simplest machine part to, say, a complete factory process or layout, there are nevertheless important considerations to be borne in mind. It is, for instance, useless to imagine that because the external features of the object drawn will be shown one need only draw an external view and trust to luck in positioning the parts revealed by cutting-away.

This is indeed as mistaken as drawing a horse or human figure and neglecting the skeleton on which the shapes depend.

As in all drawing, the construction must proceed from the internal to the external by first putting in centre lines and basing the rest of the drawing on this skeleton framework.

It is also usual to at least outline the drawing of external details even of those parts that will not appear in the completed arrangement. This will ensure that all parts are in correct relationship to one another and will enable one, starting from the outside, to erase piece by piece those details not required to be shown.

Unless requirements render it unavoidable it is always preferable not to cut, or section, circular spindles or shafts but to show them in full even if the end bearings cannot be shown. Again the necessity of indicating changes in the shape and thickness of the dissected metal should not be overlooked.

Where shading is attempted, the extent, density and nature of the shading is governed by whether its inclusion makes the form or construction of features clearer. In many cases it may be found advisable to shade only the internal features revealed by cutting and this method will be found to accentuate them rather more than if no shading is used. Further details on shading will be included in the final chapter on Illustration for Reproduction.

It will be found on occasions that considerable licence must be taken in order adequately to illustrate particular objects. One instance of this occurs where many sections of metal are cut through to reveal an inner detail and yet the successive sections are not shown. As stated earlier each case must be treated according to its merits and the sole arbiter of success is whether the drawing fulfils its function.

Fig. 24 shows a drawing of a low pressure cut-off valve in which, by cutting away, a clearer idea of both the constructional details and method of working is obtained. It will be noted particularly how the sectioning follows closely the various thicknesses of metal cut away The press button mechanism, lower right, is not shown sectioned in order not to confuse the reader but it may be mentioned that, in the original illustration, a separate cut away drawing of the mechanism was shown in order to complete the information necessary. The reader will perhaps also notice that, whilst the cover and diaphragm are shown removed from the body of the valve, they are shown vertically above the position which they would occupy when the valve is assembled. The choice of viewpoint was in this case not a difficult matter to determine inasmuch as, in order to reveal how the press button control was located in the body of the valve, it was obviously necessary to view the valve from such a position that the press button mechanism was in the foreground. Had this control been shown exactly central the foreshortening necessary would have spoilt the clarity of the details.

In order to appreciate fully the advantage of the cut-away method of illustration over the orthographic or isometric methods it is necessary to see something much more complicated than the

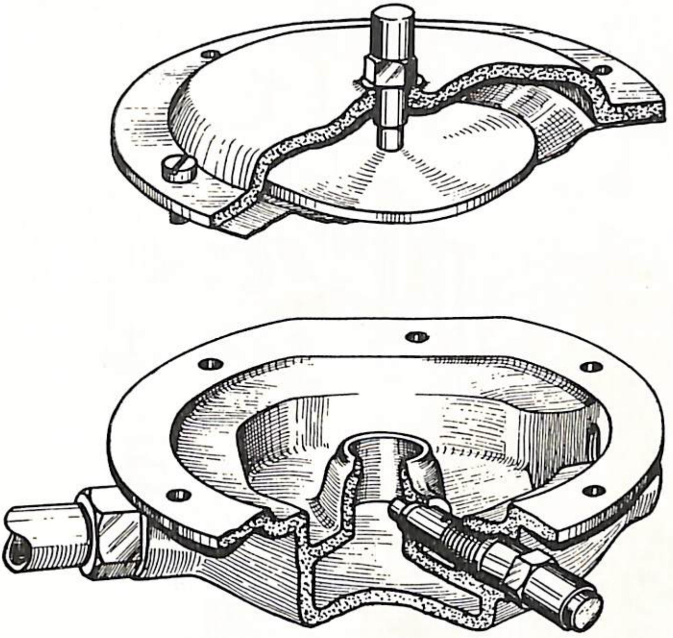

Fig. 24.

example shown in Fig. 24. Such a drawing as that shown in Fig. 25 enhances to the full the particular merits of cut-away drawing, and it will be apparent right away how easily even the layman could understand the intricate construction and working of an internal combustion motor-cycle engine. Notice how almost all the internal parts have been made plain, and that in spite of the extensive sectioning used, little doubt exists as to the appearance of almost all of the external features of the engine. The method calls for great skill, consisting of the knowledge just to what extent sectioning is desirable, necessary and possible, without losing external shape. Sometimes compromise is essential and then the draughtsman must use discretion as to the relative importance of internal and external features. Experience will prove a valuable asset in this connection and although each case will present its own problems, methods of overcoming them will soon suggest themselves.

Reference to the sectioning of the cylinder body will make clear to the reader the necessity of indicating changes in the shape and thickness of the dissected metal. This is an important point and one that is sometimes not given sufficient attention.

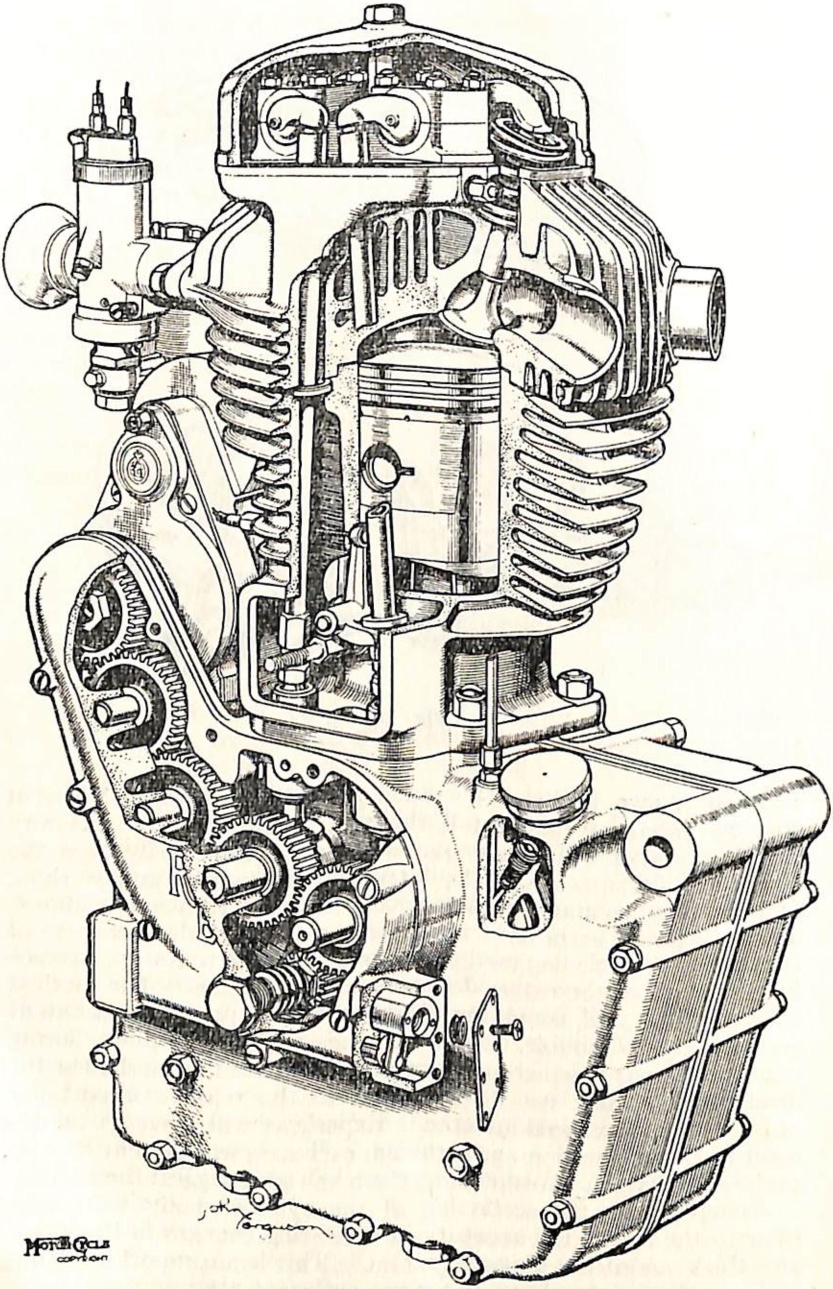

Fig. 25.

Where a projecting shaft is revealed, it is better to connect this with its bearing, if possible, rather than let it appear to be unsupported. An example of this occurs in the train of gears, Fig. 25, where most of the projecting shafts are so connected. Notice also how the dark tonal shading used within the sectioning has revealed more clearly the parts exposed.

There are many occasions in cut-away drawing, particularly of complicated machinery, where photography can be of great assistance.

The process generally used is known as the "bleach print" process and a brief description of it follows,

A lightly-printed photograph of the desired size is prepared on paper that is suitable for penwork, that is to say, a matt surface. A photograph of low contrast is desirable, because it will show full details in both the shadows and high lights. The photograph is then drawn over as accurately as possible, using waterproof ink. The "drawing-in" being completed, the photographic base is then bleached out, generally with a solution of potassium ferricyanide and sodium thiosulphate ("hypo") leaving the waterproof ink lines exactly as drawn. During the time the photograph is wet, *i.e.*, during bleaching, washing and drying, it is essential that the surface should not be touched, as otherwise the ink lines may be blurred. Almost any photographic firm will prepare a print of right size, on suitable paper, and also will undertake the subsequent bleaching process; but many amateur photographers would prefer, no doubt, to do all for themselves. Much time is saved by this method and accuracy is ensured, and it is especially of value when the "cut-away" system of drawing is intended, as it leaves little chance of error in the positioning of details which would appear in the sectioning.

## Chapter VII.

## ILLUSTRATION FOR REPRODUCTION.

This last chapter is given over to the consideration of the requirements and methods of drawing when illustrations are to be reproduced in one form or another. Generally speaking a greater degree of accuracy and finish is essential if the drawing is to justify both the expense and the draughtsman's reputation.

The linework generally should be drawn with the use of instruments whilst freehand work should be kept well within the capabilities of the draughtsman. If the drawings are required for reproduction in periodicals or analogous publications, they are usually drawn larger than the finished reproduction. The amount of reduction will vary in individual cases, but as a general rule, block makers prefer the original drawing to be sufficiently large to permit of a lineal reduction in printing to two-thirds of that size.

This reduction must be borne in mind when preparing the illustration, and all lines should be drawn of a sufficient thickness to ensure clarity in the reduced reproduction. All lettering or wording used on the illustration must also be printed correspondingly larger. In most printing processes, especially the ones using a cheaper variety of paper, a noticeable thickening of the lines will take place, and if these are very closely spaced "filling up" or muddiness will be evident. This can, of course, be avoided by attention to spacing, particularly of shading lines, when preparing the original drawing. It is always a good idea to compare printed copies of illustrations with the originals in order to determine how differences between them can be avoided in future drawing.

A useful instrument in assessing the clarity of a drawing that is to be reduced in printing is the reducing or diminishing glass. This may be obtained with a lens diameter of some two or three inches, and in use gives one a very accurate idea of the appearance of a drawing when it is reduced in size.

In the more finished drawings prepared for reproduction, shading by one means or another is almost imperative, not only to give a more pleasing appearance but to assist in giving form or solidity to the object drawn. Indeed some form of shading is necessary, in some instances, to accentuate changes in shape which cannot be expressed in mere outline alone.

The degree of shading desired or necessary depends to a great extent on the nature of the drawing and the purpose for which it has been produced, and will vary in complexity from the more subtle suggestion of curves to the bolder general shading of every feature in the object.

A rough classification of different surfaces from the point of view of the conventional methods of shading adopted in each case is given below.

## A. Shading of Irregular Curved Surfaces.

This refers to curved surfaces other than regular geometrical ones, such as are to be found in the cast or forged features of machinery or machine tools. The frame of a power press or the cast standards of a lathe provide examples of this type of surface. One treatment adopted consists of drawing freehand lines which should follow the contours of the curves and thus indicate the form and changes in shape of the surface.

## B. Shading of Regular Curved Surfaces.

Objects of spherical, cylindrical and conical shape come under this heading.

In the case of spherical or semi-spherical surfaces, the shading can take either the form of lines, see Fig. 26 (*a*), or the conventional block shading, with high lights indicated as in Fig. 26 (*b*). The latter method is very effective for certain subjects, although care is needed both in placing the high lights and shaping them. It must be remembered that the boundaries of these high lights are curved and not straight and that they follow the contour of the sphere. This method is not recommended for large objects. In the shading of cylindrical objects the curvature of the surface may be emphasised by variations in both the thickness and spacing of the shade lines along the cylinder, see Fig. 27 (*a*).

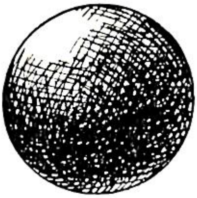

**Fig. 26 (a).**

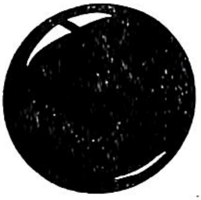

**Fig. 26 (b).**

The distinction between the methods used in Section A and this case of cylinder treatment should be noted. In the latter case the shade lines do not follow the contour of the curved surface, but are drawn parallel to the axis. This is largely a matter of

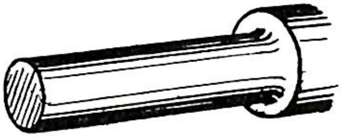

Fig. 27 (a).

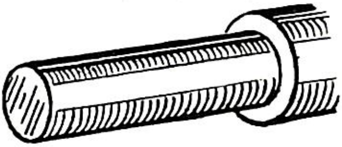

Fig. 27 (b).

expediency, it being much easier to draw straight lines parallel to the axis than curved freehand ones, each of which must be a portion of the ellipse constructed at that section. Sometimes, however, a combination of the two methods is used, see Fig. 27 (*b*), particularly when cross hatching is used for plane surfaces.

Fig. 28 gives a rather more complicated example of this method in use.

The conic form is best shaded by lines following the contours of the curves rather than by lines tapering towards the smaller end. In this way closing up of the lines in "reduction" when printed would be avoided.

## C. Shading of Plane Surfaces.

Generally speaking, plane surfaces need little shading except in so far as it is necessary to distinguish between similar surfaces in different planes. This perhaps is best illustrated by an example in which vertical parallel lines have been used to cover shaded plane surfaces (see Fig. 29).

It will be seen that in this case, all faces in the same plane have been shaded, whilst the other planes (with minor exceptions) have been left blank. The reader should appreciate how this system, though a conventional one, does give an approximation to truth, although of course it could not possibly be regarded as strictly accurate in representation.

## D. Shading of Polished Surfaces.

The impression of both polish and transparency can be achieved by the same method of shading and consists of parallel lines of unequal length usually at an oblique angle. Fig. 30 shows an example of this applied to a guard for a drilling machine.

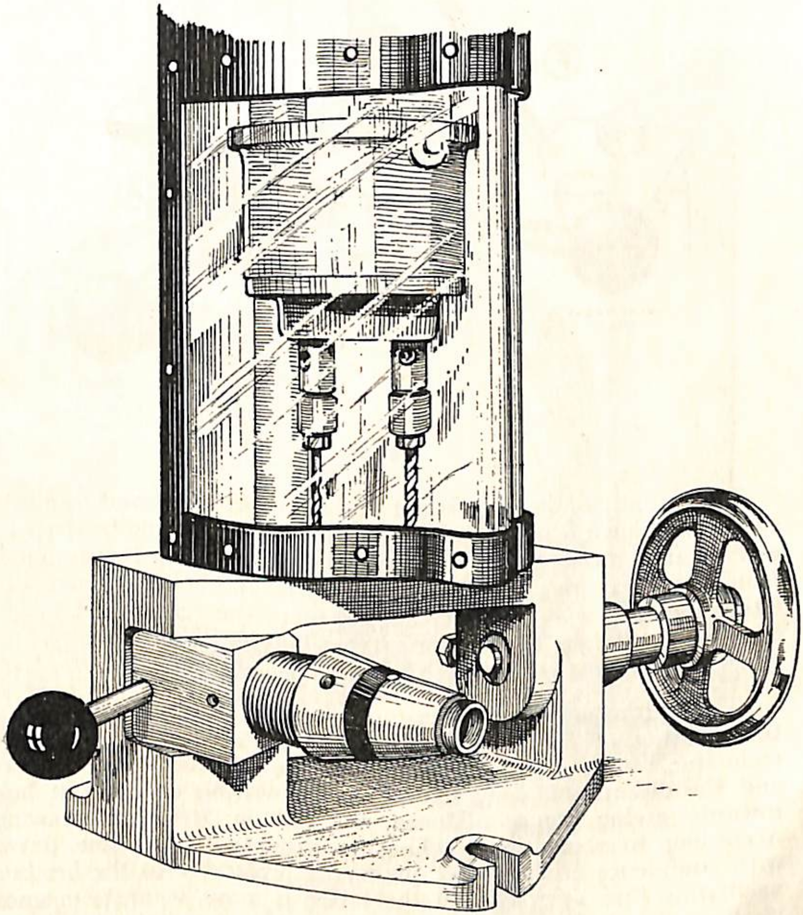

Fig. 28.

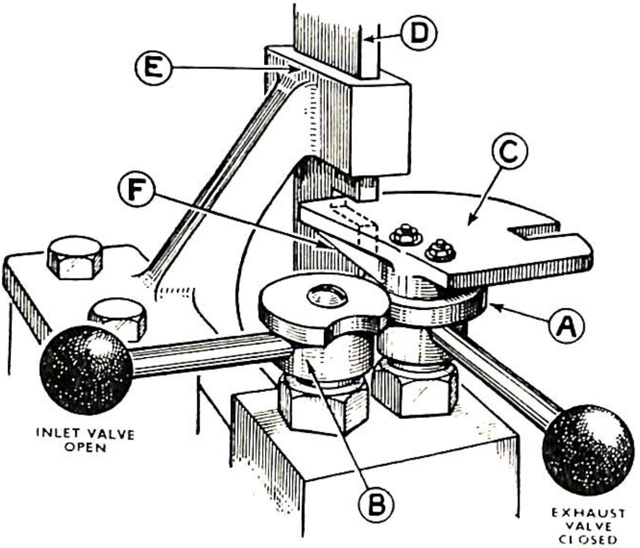

**Fig. 29.**

The subject of shading is not one for which hard-and-fast rules can be laid down readily, and the examples given should be regarded as typical of the more simple conventions which help the draughtsman to achieve the object of giving form and solidity to shapes. Other methods may suggest themselves to the reader and in any case he is advised to experiment for himself, and select a form which comes most readily to his pen or pencil.

The old-fashioned penmanship provides excellent practice in the drawing of curves and helps also towards mastery of line technique. The subtle variations in the thickness of line used and the essential flowing nature of the writing cannot but help towards giving the confidence required in freehand drawing. According to some art teaching, a wrongly placed line drawn with confidence and of good quality, is preferable to the hesitant vacillating line, even though the latter is more accurate geometrically. In dealing generally with machinery and engineering appliances, accuracy may be a prime consideration but, nevertheless, the ideal must be kept in sight.

Whilst most of the comments in this chapter have been written from the point of view of pen drawing, it must not be forgotten that many artists and some draughtsmen make greater use of the brush than the pen. It will be found that in capable hands the brush has, perhaps, even greater subtlety than the pen for this

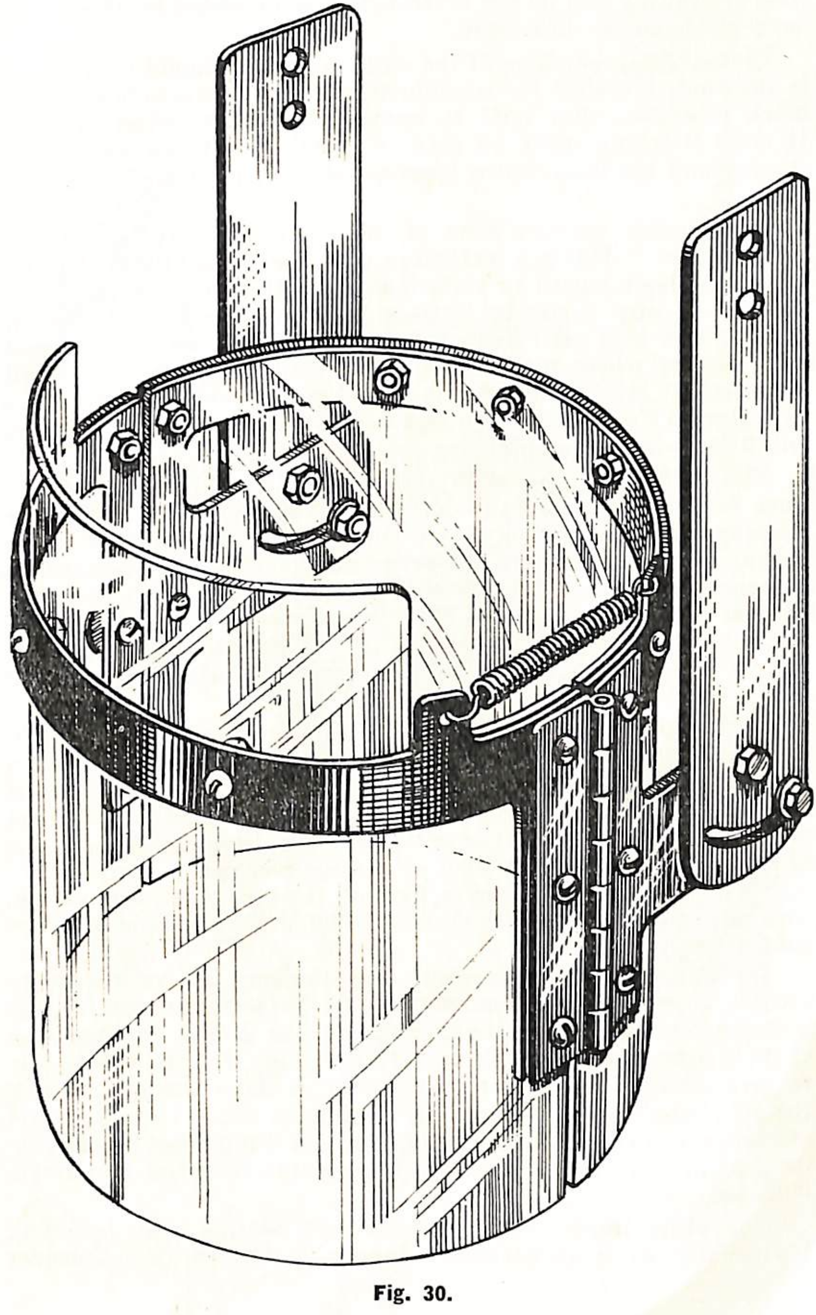

Fig. 30.

class of drawing and its use is strongly recommended for those who have mastered its difficulties.

Closely drawn shading of the criss-cross type should be avoided in drawings intended for reproduction as, by reproduction in the block processes, they tend to appear as smudges when printed. If cross hatching must be used, it should be drawn with open spacing and the lines drawn approximately at right angles to each other.

There exists another form of shading which may be used in certain cases, This is a method in which only dead black shading is used without regard to variations in depth of tone or degree of shadow on any particular surface. It is somewhat similar in technique to that used frequently in poster work and is employed with success where mass is important and an absence of detail immaterial. It has the additional advantage that it reproduces well, due to the effective contrast between high lights and shadow on all faces in the same plane,

The ability to appreciate the form of an object depends to some extent on the law of contrast : so to produce a good clear drawing, artificial methods of accentuating contrast often prove useful, especially in cases where it is desired to give prominence to some detail or object in the general picture. An excellent method of attaining this end is to draw the relatively unimportant features with thin lines and leave them unshaded. The important feature is then drawn in with thicker lines and shaded in the normal way. See Fig. 31.

It should be noted that where shading has been mentioned in this chapter, it has been taken to mean the absence of light on a particular part of an object rather than the shadow cast upon it by some detail and reflected in true outline. This latter effect introduces problems of perspective rather beyond—though not necessarily more difficult than—the stage reached in Chapter II., and generally the technique in forming the cast shadow is no less conventional than the methods of shading already used in ordinary contrast shading.

In some drawings, however, cast shadows are of relatively greater importance than in others If, for instance, the base of a stanchion standing on the ground is to be drawn, the inclusion of the shadow cast by the base of the stanchion, Fig. 32, will appear to give stability to the structure, whereas if no shadow is used, the stanchion might appear to be floating in air, The suggestion of anchoring an object to the ground or floor is produced by drawing its shadow, and many drawings appear unsubstantial due to its omission,

One other important use of the cast shadow may be cited, particularly as it is necessary to use it frequently Consider

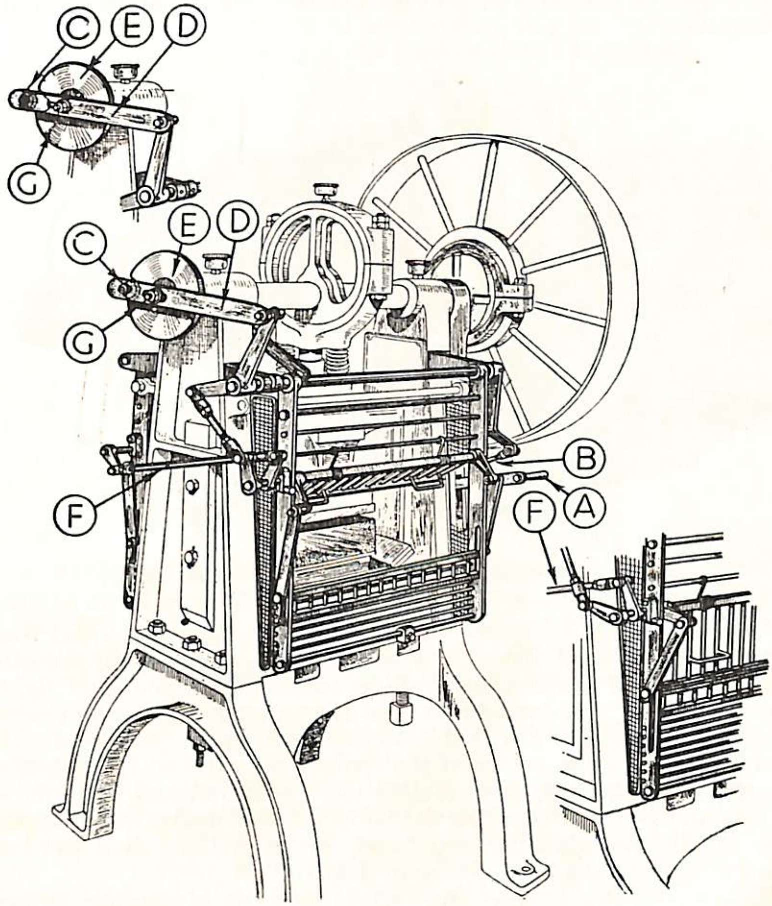

Fig. 31.

Fig. 33, which illustrates a portion of a drill spindle. If no line shading is used, the essential roundness of the spindle can be expressed quite simply, by the inclusion of the shadow cast by the spindle bearing. It is important, of course, that the lower edge of the shadow should be curved, as shown, for this is the whole point of the method. Similar treatment can be applied to all cylindrical or curved objects at the points where the shadows would be cast.

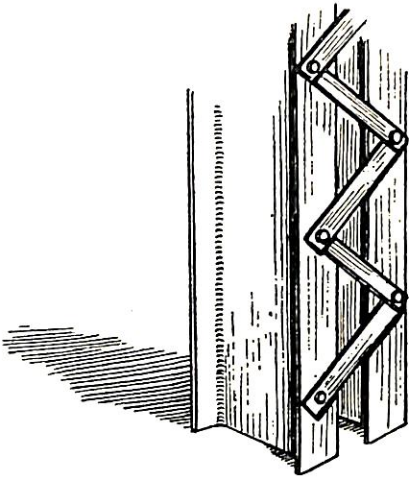

Fig. 32.

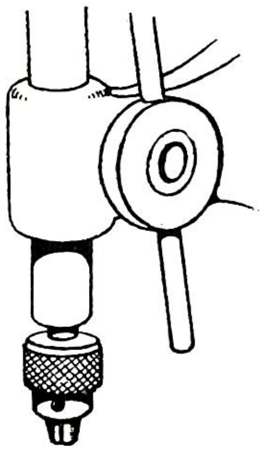

Fig. 33.

The extent to which use is made of the cast shadow, apart from the instances cited above, is based on a commonsense application of the laws of illumination. First consider the source of light; its magnitude, *i.e.*, daylight, or light from a point such as an electric lamp; the position of the object in the light rays; and finally the natural contrast in colour of the component parts of the object or machine. When all these factors have been reduced to terms of black and white, decide how dense the darkest shades are to appear on the finished drawing, put these shades in first, then continue to the lightest shades, in order of density.

So far in this chapter the various methods of shading surfaces have been shown but nothing regarding shading to represent particular materials or textures. In certain cases it may be necessary to distinguish between say cast surfaces and mild steel. At best the method can only be conventional but generally speaking cast surfaces are shown by a pen or brush stripple consisting of irregularly spaced dots—the spacing determining whether the surface is in the shadow or well lit. This method of shading can look extremely effective when well executed but can be tedious when large surfaces require covering. The same method can be used for other materials, for instance leather, and it will be found useful in many other cases where subtlety of tone is required.

Fig. 34 illustrates for example the use of a pen stipple to give form by shading to two types of footwear. It will be found that in the ink drawing of this type of subject a much greater subtlety is possible than by the use of line shading, but the method requires much skill and knowledge to be used to the best advantage.

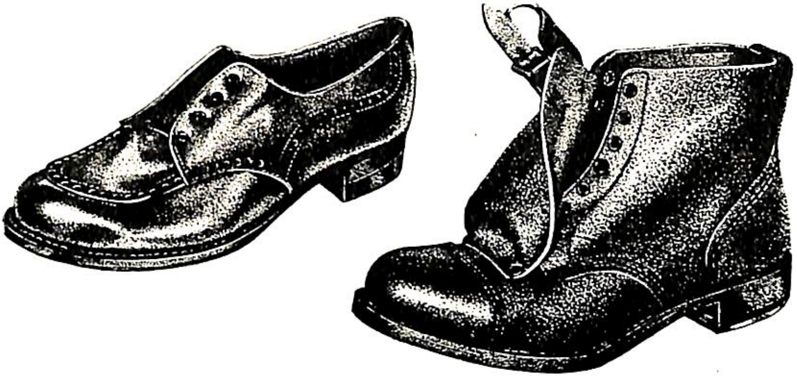

Fig. 34.

The burst abrasive wheel shown in Fig. 35 is a good example of the use of a pen stipple in illustrating texture, the gritty nature of the abrasive being a particularly apt subject for its use. It will also be found that a pleasant contrast between the machine and the wheel is provided by the different techniques employed in illustrating them.

Fig. 36, in which a strip of Ferodo material is illustrated in use on a press slide, provides another example where the pen stipple technique is used effectively to show texture.

A method of giving form, emphasis, or texture to objects drawn in line that is much used in studios is that using mechanical tints, the use of which is illustrated in Fig. 37. In this process, the draughtsman indicates to the printer the area to be covered by the mechanical tint by outlining the area with blue pencil and then indicating alongside which particular tint is required. Identification of the tint is given usually by a number which is taken from a specimen sheet or book issued by the particular maker of the tints. Various types of tints are available ranging from a simple screen of dots to the most elaborate texture. They are particularly useful in saving time when large areas are required to be covered

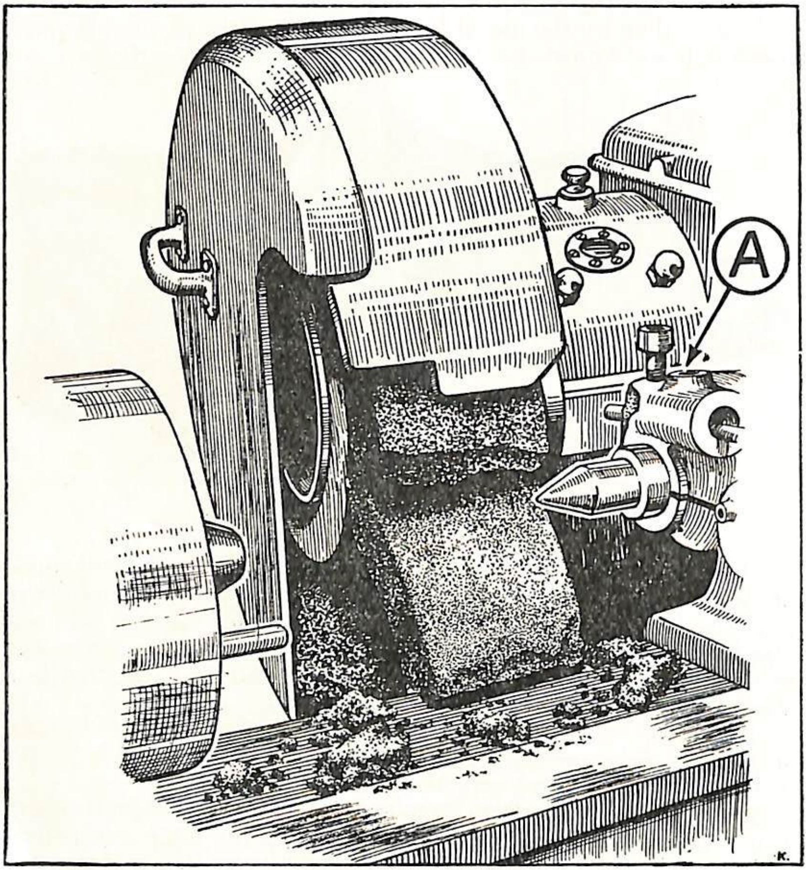

Fig. 35.

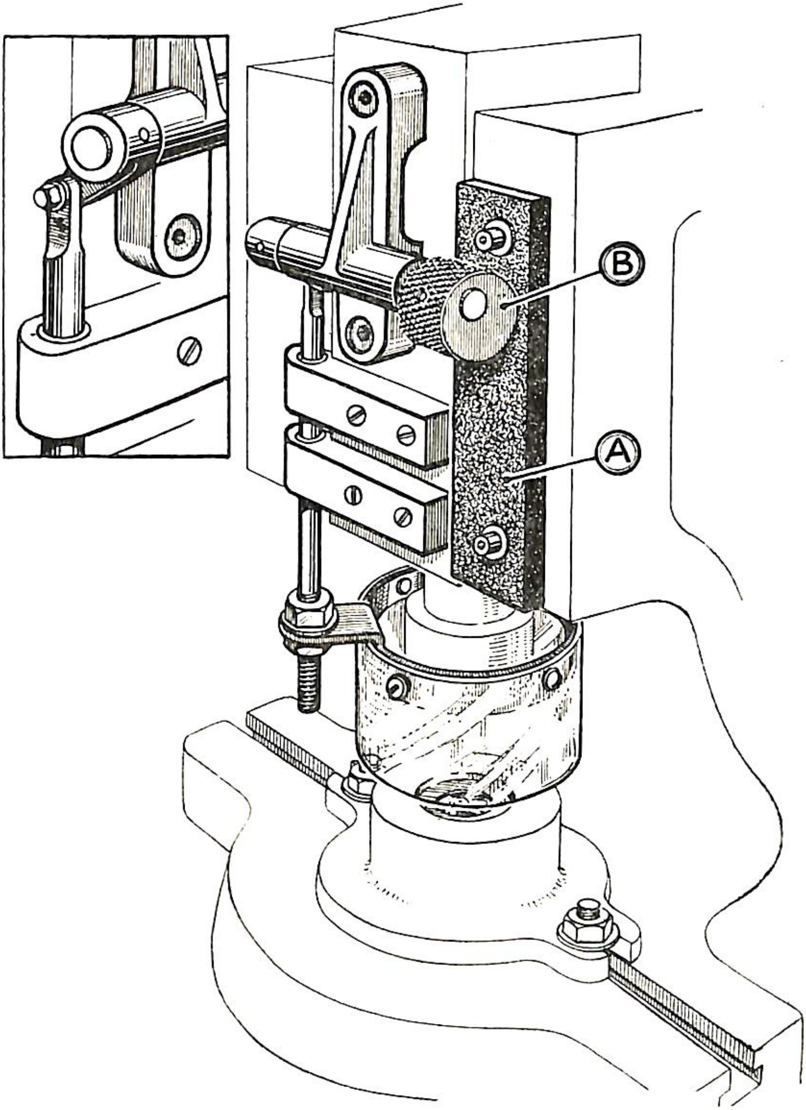

Fig. 36.

with a tone, and give a clean uniform appearance which prints well in reproduction. Care is needed in the choice of tint required and it must be remembered also that although the drawing may be reduced in reproduction the tint appears the same size or density as on the specimen sheet.

So far in this booklet little mention has been made either of layout or composition. Whilst it is true that technical illustration is not in the category of pure art, nevertheless a good layout and composition is much to be preferred to a drawing in which consideration has not been given to these factors. Where the drawing contains more than one component due care in placing these with respect to one another and to the borders of the drawing allows one to achieve a balance which is pleasing to the eye. In many cases where the choice of viewpoint or the nature of the drawing is such as to make a good layout difficult the careful placing of any lettering or inserts required may help to redress this.

On drawings that will be subsequently printed, hand lettering is rarely used, instead the wording required is placed in its correct position in pencil and instruction given to the printer as to size and style of typesetting required.

Many drawings which have been well executed in outline are subsequently spoiled by careless shading, and in cases like these the use of mechanical tints, in place of hand shading, helps considerably in keeping a good standard in the reproduction.

A good example of this is in the treatment of skies in ink drawings, Fig. 38. Unless the paper on which the drawing is to appear is of good quality with a very smooth finish the lightest of lines drawn to represent cloud outlines will appear far too clumsy in reproduction. Mechanical tints provide a happy solution to this problem and are usually used in such a way that the clouds appear white, the rest of the sky carrying a mechanical tint of the appropriate intensity

On completion of the drawing it is usual to cover it with a protective overlay to ensure that the printer receives it in the condition in which it left the draughtsman, *i.e.*, clean and free from fingerprints.

This chapter has been devoted to the methods employed in achieving a higher standard of "finish" in drawings which are intended for reproduction, but the placing of the viewpoint affects the appearance of an object even more than the shading. Here again it is useless to dogmatise by laying down definite rules on the subject, for they would not fit all cases. Viewpoint plays its part in the achievement of effect and generally it will be found that a low viewpoint gives a more imposing and massive effect to a building or structure than a high one. A study of illustrated advertisements, and particularly those dealing with houses, will

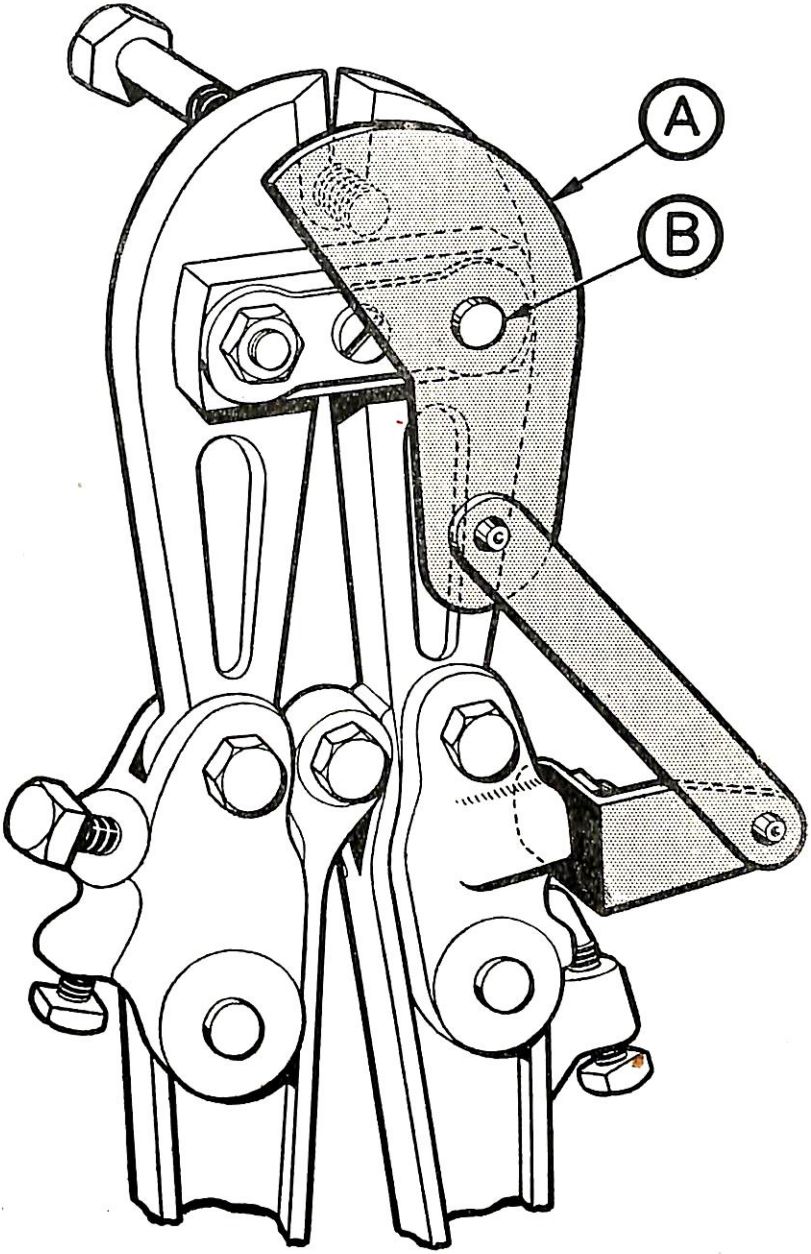

Fig. 37.

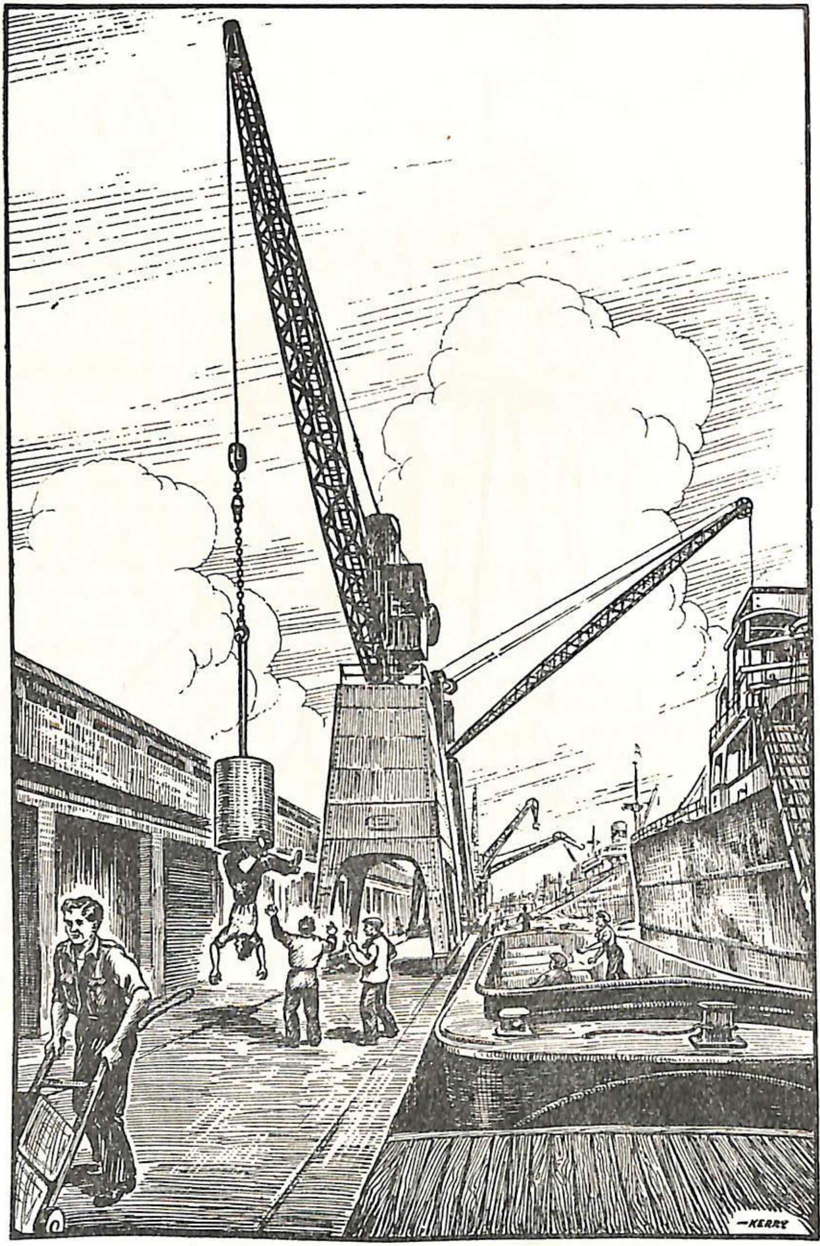

Fig. 38.

no doubt convince the reader of this fact (Fig. 39). Conversely, a high viewpoint gives a dwarfing effect, and massive structures lose their significance—the aerial view provides an exaggerated example of this.

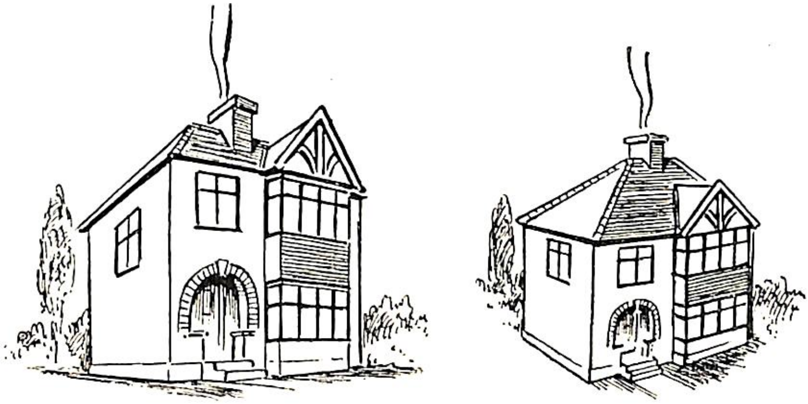

Fig. 39.

The purpose of this digression is to suggest to the reader how a preliminary study of the question of viewpoint may have some bearing, and sometimes an important one, on finished "effect."

Occasionally the draughtsman may be required to make a freehand copy of a photograph, either as a whole or of some particular feature in it. Assuming the photograph is the right size for the purpose, the method of tracing provides a ready means of obtaining at least accurate outlines, and in some cases the whole of the necessary details. The objection most frequently raised to this method is that the tracing paper used, although of good transparency, has not the surface suitable for pen drawings. This is not true of the best tracing paper, which has good transparency and a reasonable pen drawing surface, but like all other good things, it is expensive. There is on the market a transparent plastic material known as "Eutholon" which is supplied in rolls, has a surface rather like tracing cloth, and has excellent photographic qualities. This is eminently suitable for tracing from photographs and reproduces well in printing.

Whilst it is not the author's intention to include the subject of figure drawing in this booklet, it is realised that draughtsmen have occasionally to use figures in their drawings. Such treatment is probably of a simple nature and necessarily so, since proficient figure drawing is an art in itself, requiring years of study.

Fig. 40 shows an illustration in which it was necessary to include a figure, the drawing of which has been rather simplified.

The use of a fully-jointed lay figure will prove of invaluable assistance in illustrating figure action as the head, trunk, arms and legs can be set to any desired position. In all figure drawing, whether from life or from lay figures, the basic form, trunk, limbs, etc., should be drawn first in their correct position and the clothing added later.

## APPENDIX.

The frontispiece illustration and Figures Nos. 28, 30, 31, 34, 35, 36, 37, 38 and 40 are reproduced by courtesy of the Controller of H.M. Stationery Office. These drawings have appeared in publications of the Factory Department, Ministry of Labour and National Service.

Figures 34, 35, 38, 40 and the frontispiece have appeared in the series "Accidents," published quarterly, price 1/-.

Grateful acknowledgment is made to the publishers of *The Motor Cycle* for permission to reproduce Fig. 25 ; to Messrs. Alfred Herbert Ltd., Coventry, for allowing the inclusion of Fig. 8, and to Messrs. Keith Blackman, Ltd., for Fig. 24.

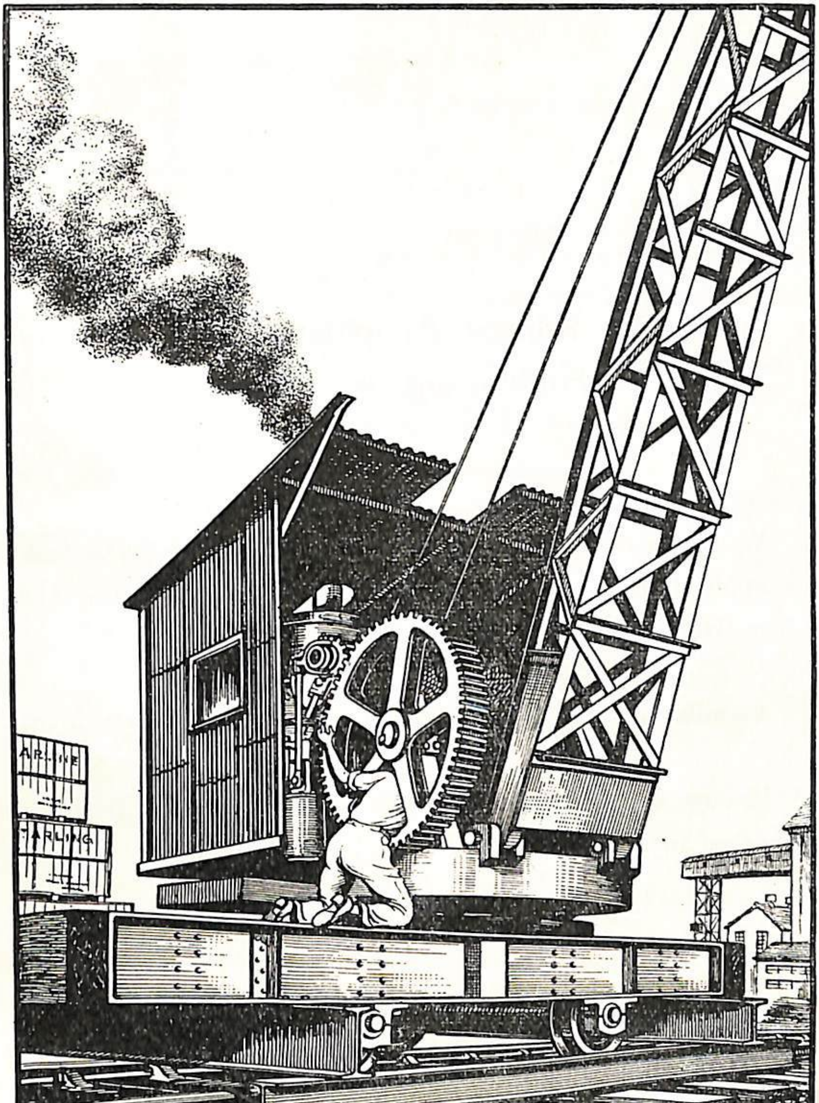

Fig. 40.

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2. Deflection of Shafts and Beams.
3. Deflection of Shafts and Beams (Instruction Sheet). } Connected.
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5. Horse-Power of Leather Belts, etc.
6. Automobile Brakes (Axle Brakes).
7. Automobile Brakes (Transmission Brakes). } Connected.
8. Capacities of Bucket Elevators.
9. Valley Angle Chart for Hoppers and Chutes.
10. Shafts up to $5\frac{1}{2}$ inch diameter, subjected to Twisting and Combined Bending and Twisting.
11. Shafts, $5\frac{3}{4}$ to 26 inch diameter, subjected to Twisting and Combined Bending and Twisting.
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14. Spiral Springs (Compression).
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16. ,, ,, (Plate Clutches).
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19. Internal Expanding Brakes. Angular Proportions for Self-Balancing. } Connected.
20. Referred Mean Pressure Cut-Off, etc.
21. Particulars for Balata Belt Drives.
22. $\frac{7}{8}''$ Square Duralumin Tubes as Struts.
23. 1″ ,, ,, ,, ,,
24. $\frac{3}{4}''$ Square Steel Tubes as Struts (30 ton yield).
25. $\frac{7}{8}''$ ,, ,, ,, (30 ton yield).
26. 1″ ,, ,, ,, (30 ton yield).
27. $\frac{3}{4}''$ ,, ,, ,, (40 ton yield).
28. $\frac{7}{8}''$ ,, ,, ,, (40 ton yield).
29. 1″ ,, ,, ,, (40 ton yield).
30. Moments of Inertia of Built-up Sections (Tables).
31. Moments of Inertia of Built-up Sections (Instructions and Examples). } Connected.
34. Capacity and Speed Chart for Troughed Band Conveyors.
35. Screw Propeller Design (Sheet 1, Diameter Chart).
36. ,, ,, ,, (Sheet 2, Pitch Chart).
37. ,, ,, ,, (Sheet 3, Notes & Examples). } Connected.
38. Open Coil Conical Springs.
39. Close Coil Conical Springs.
40. Trajectory Described by Belt Conveyors (Revised, 1949).
41. Metric Equivalents.
42. Useful Conversion Factors.
43. Torsion of Non-Circular Shafts.
44. Railway Vehicles on Curves.
46. Coned Plate Development.
47. Solution of Triangles (Sheet 1, Right Angles).
48. Solution of Triangles (Sheet 2, Oblique Angles).
49. Relation between Length, Linear Movement and Angular Movement of Lever (Diagram and Notes).
50. ,, ,, ,, ,, ,, ,, (Chart).
51. Helix Angle and Efficiency of Screws and Worms.
52. Approximate Radius of Gyration of Various Sections.

53. Helical Spring Graphs (Round Wire).
54. ,, ,, ,, (Round Wire). Connected.
55. ,, ,, ,, (Square Wire).
56. Relative Value of Welds to Rivets.
58. Graphs for Strength of Rectangular Flat Plates of Uniform Thickness.
59. ,, Deflection ,, ,, ,, ,, ,,
61. Deflection of Leaf Spring.
62. Strength of Leaf Spring.
63. Chart Showing Relationship of Various Hardness Tests.
64. Shaft Horse-Power and Proportions of Worm Gears.
65. Ring with Uniform Internal Load (Tangential Strain) Connected.
66. ,, ,, ,, ,, (Tangential Stress)
67. Hub Pressed on to Steel Shaft. (Maximum Tangential Stress at Bore of Hub).
68. Hub Pressed on to Steel Shaft. (Radial Gripping Pressure between Hub and Shaft).
69. Rotating Disc (Steel) Tangential Strain. Connected.
70. ,, ,, ,, Stress.
71. Ring with Uniform External Load. Tangential Strain. Connected.
72. ,, ,, ,, ,, ,, Stress.
73. Viscosity Temperature Chart for Converting Commercial to Absolute Viscosities. Connected.
74. Journal Friction on Bearings.
75. Ring Oil Bearings.
76. Shearing and Bearing Values for High Tensile Structural Steel Shop Rivets, in accordance with B.S.S. No. 548/1934.
78. Velocity of Flow in Pipes for a Given Delivery. Connected.
79. Delivery of Water in Pipes for a Given Head.
80. (See No. 105).
81. Involute Toothed Gearing Chart.
83. Variation of Suction Lift and Temperature for Centrifugal Pumps.
89. Curve Relating Natural Frequency and Deflection.
90. Vibration Transmissibility Curve for Elastic Suspension. Connected.
91. Instructions and Examples in the Use of Data Sheets, Nos. 89 and 90.
92. Pressure on Sides of Bunker.

93-4-5-6-7. Rolled Steel Sections.

98-9-100. Boiler Safety Valves.

102. Pressure Required for Blanking and Piercing.
103. Punch and Die Clearances for Blanking and Piercing.
104. Nomograph for Valley Angles of Hoppers and Chutes.
105. Permissible Working Stresses in Mild Steel Struts to B.S. 449, 1948.
106. Compound Cylinder (Similar Material) Radial Pressure of Common Diameter (D1).
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